What's in this issue-

Chevrolet wanted to secure **greater refinement of grain structure and a more desirable grain flow of metal** to give better characteristics in gear teeth for its second speed transmission gears. How this was done is outlined on page 584-585.

Chevrolet has developed **standards for metallurgy, tools, engineering and non-productive materials.** How these standards are set and applied is told on page 551.

Four cylinder block surfaces are broached in a special Cincinnati horizontal machine at a rate of 60 pieces an hour at Chevrolet's Tonawanda plant, which is the last word in mechanical efficiency. A description of this **broaching operation and of the broaching tools** used is on page 559 with explanatory pictures on page 560.

High chrome-silicon steel valves are made by Chevrolet at Bay City. The story of their **extrusion, machining and inspection** is in picture form on pages 572-573.

Do you know how a new automobile is developed? It's far from a simple process; requiring a start a year or a year and a half before the car is introduced on the market. Details of the process are on page 542.

There's always a lot of mystery surrounding the manufacture of experimental cars. **Chevrolet for the first time lifts the veil concealing its experimental shop** at Detroit and tells what happens there on page 545. There are excellent photographs too.

Gas carburizing is done automatically by Chevrolet at Muncie, Ind., in a furnace of unique design which uses a brick chamber instead of an alloy muffle. The brick chamber serves also as a cracking chamber. A complete description of the furnace, with a line drawing of it, is on page 592.

Perhaps you have had headaches because of **bottlenecks in your plant.** Chevrolet doesn't have any in a plant which produces 40 different models according to seasonal demands. Moreover it doesn't carry large inventories of finished parts. How Chevrolet licks these problems is told on page 608.

How much do you know about the use of **presses for forging operations?** Chevrolet press-forges ring gears for its rear-end assembly in three operations. See page 578.

Ingenious methods of welding car bodies are used at the Fisher Body plant at Baltimore which assembles bodies for Chevrolet. Photographs of the various welding machines are on pages 624-625.

Multiple drilling is extensively employed by Chevrolet. Look on pages 562-563 for good examples in picture form.

COMING

Frank Oberkoetter Studios

L. B. Neumiller

Few companies have done a better job of industrial relations than Caterpillar Tractor. Lately, its employee service work has been intensified, seven divisions being correlated under one head who is responsible for supervision of employment and for medical, safety and training activities. Each worker is given full opportunity to feel that he is helping turn out a finished machine of which he can feel proud. In the next issue L. B. Neumiller, vice-president of Caterpillar, brings you the story in his own words. It will give you some stimulating ideas which you may want to use in your plant.

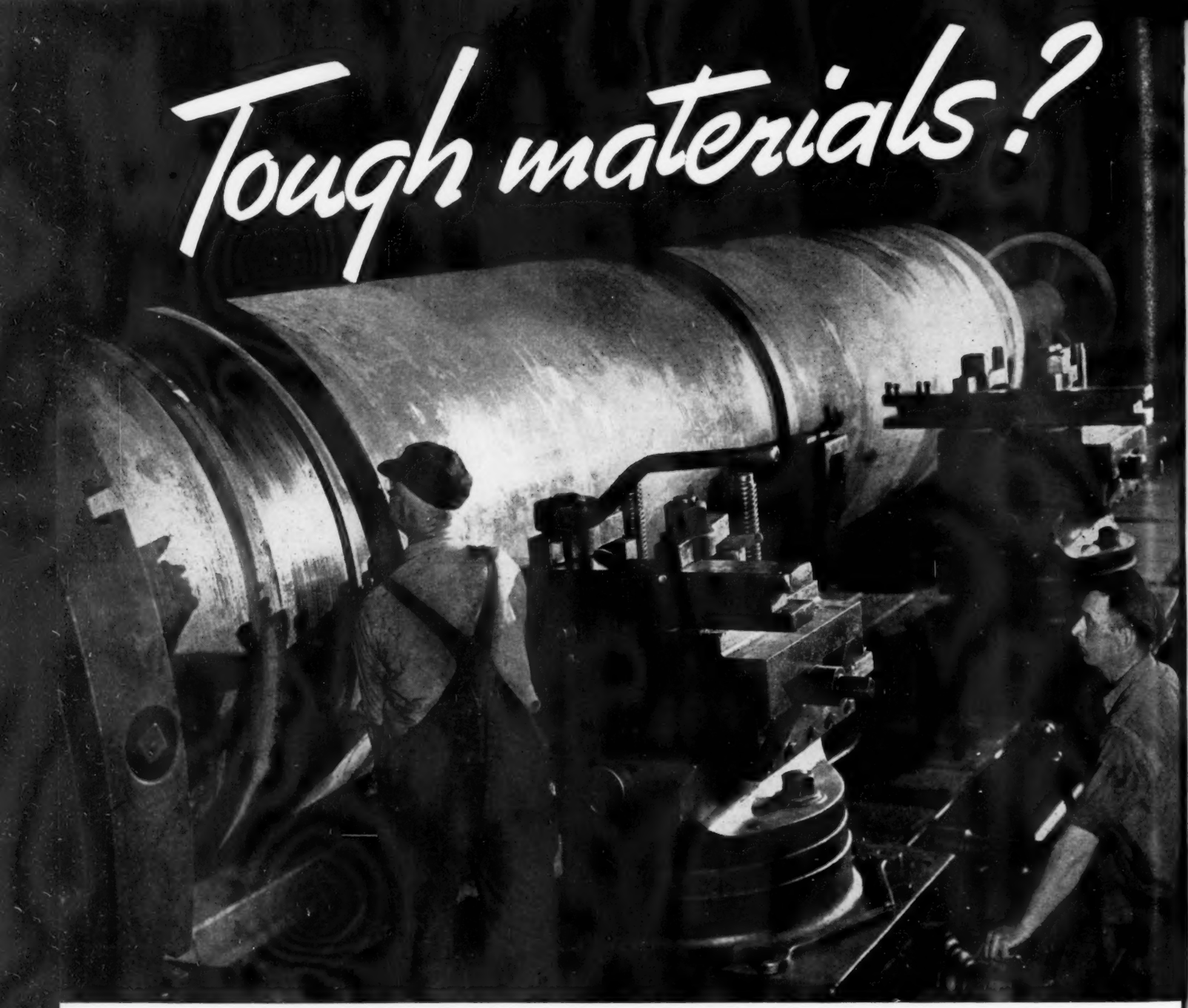
In making 8400 square tubular supports for steel shelving, a production welding shop worked out a pneumatic method of holding 22-foot channels so that they would not warp while being welded. An article in the next issue describes this new method, which made possible finishing the job ahead of time with profit for both contractor and welder.

Shaving is a squaring up operation of the sheared edges of a steel blank and is applied to outside edges of parts as well as to edges of holes for bearing purposes. Walter Kassebohm, superintendent of the tool division of Marchant Calculating Machine Company, tells you in the next issue about shave dies and their application.

Ford is experimenting with centrifugal casting of transmission cluster gears. All of Ford's skill and ingenuity have been put to work to produce a cast product superior to the forged product. This has involved development of new foundry practice at the Rouge plant. Just what Ford has done is described in an exclusive article obtained by one of our editorial staff men who visited Dearborn recently.

There are other good features in the next issue. The small shop operator will find helpful the article on "Short Cuts for the Small Shop." It is good practical stuff which can be applied immediately to increase shop efficiency. Another article, which is largely a pictorial presentation, shows what the Heald Machine Company does in packaging its machine tools for shipment to customers. The story takes the reader from the moment that the machine is finished and tested until it is ready to be moved out of the plant.

Tough materials?



BETHLEHEM SPECIAL
takes them in its stride—

BETHLEHEM Special High-Speed Tool Steel is a super-cutting steel that holds its edge when the going is heavy, keeps production schedules from bogging down even when machining special steels, high-test iron castings and similar stubborn materials that take it out of tool steel. Bethlehem Special keeps time out for grinding at a minimum. It stands up through deep cuts at high speeds with fast feeds in spite of high temperatures.

Bethlehem Special is the oldest of all high-speed tool steels and was first manufactured in 1900. Since that time, research has gone on continuously and there has been consistent improvement in cutting efficiency.

In the complete range of Bethlehem Tool Steels, you will find other grades that you can count on to give equally efficient, dependable service in their particular fields of application.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY

AMERICAN MACHINIST

ESTABLISHED 1877

F. H. COLVIN • K. H. CONDIT • BURNHAM FINNEY, Editors

Under Free Enterprise

THIS MODERN PLANT NUMBER of *American Machinist* presents to our readers the story of the Chevrolet Motor Division of the General Motors Corporation. It tells how Chevrolet grew from a pigmy back in 1911 to one of the giants in the automotive industry, how it manages its huge and vastly scattered plants, how its cars are engineered and built to exacting specifications, and how modern science and precision equipment and machinery have been used to reduce production costs and ultimately to lower Chevrolet's prices to the consumer.

What Chevrolet has accomplished in twenty-seven years is eloquent testimony to what can be done under the American system of free enterprise. While Chevrolet was building the widespread organization which it now possesses, was expanding its sales at an amazing speed and was paying top-notch wages to its workers, it did not operate under the throttling hand of government management or control. It was free to do business in the way which Americans had known since the founding of the Colonies.

The facts speak for themselves as to whether that system was beneficial to the country. The first Chevrolet car sold for $2,150 at the factory. Today a Chevrolet car so far superior in performance, dependability and comfort to the first one that there is no basis for comparison, sells for only $648 delivered at Flint. Management and engineering skill, plus modern tools of production, have brought the Chevrolet car—and, of course, other cars too—within the price range of the masses.

If we go back only to 1929, we see a car which to our eyes appears out-moded, and a ride in it would prove just how out-of-date it is. Since then there have been many improvements in automobiles. Car interiors are larger, engines more powerful, springs better, paint finish more lasting, gear shifting easier and bodies and tops stronger and safer. Yet today's much better car costs $54 less than the '29 car, though labor and materials expenses are the same. That is what technological advances have done for the consumer in the last nine years.

WE VENTURE the opinion that the automobile industry, Chevrolet included, has become the exemplar of American business at its best because it had free rein — and a profit incentive — to do great things. Its traditionally restless energy, youthful enthusiasm and inventive and creative genius were turned loose without reservation and the result was that America's No. 1 consumer industry literally sprang into being overnight. Could that have been done under a completely controlled economy where one cannot turn around without consulting Washington or an industry board? We doubt it.

What technological advances and mechanized machinery have done to make possible the smooth operation of Chevrolet's car and to put that car within the reach of the factory worker as well as of the well-to-do, is related in the succeeding pages. We emphasize that these achievements could not have happened if Chevrolet had not been willing to keep its factories constantly modernized and if its management had not been in the hands of men who recognized how vital modernization is to the success of American industry.

Gaging Business

A TURN in sentiment toward the hopeful side is reported from important metal-working industries. This is traceable to the belief that business has touched bottom and that an upturn may occur in the fall. It is supported by prolongation of automobile assemblies of current models a month or more beyond the time anticipated and by the resistance that steel operations are showing to a seasonal decline. Prospects of government contracts arising from the federal pump-priming and rearmament programs have helped to brighten the outlook.

In fact, government orders already are flowing at an increasing rate into various metal-working industries. Shipbuilding in particular is getting set for a boom. Airplane factories are running full time. Machine tool sales have slipped further this month, but still are bolstered by export orders. Farm equipment and tractor sales, having decreased seasonally, are currently about 30% behind 1937 and for the year to date are 20% under last year. Business Week's index of business activity is at 60.6 compared with 59.6 two weeks ago.

NEW ENGLAND — Equipment buying has improved slightly. Machine tools sold at the Austin-Hastings show in Boston totaled about $70,000. Institutional building construction is on the mend, while sales of industrial heating apparatus have revived moderately. Preliminary inquiries are out for boring mills and heavy and sensitive drills for naval work to be started soon.

CINCINNATI—Thanks mostly to foreign business, much of it Russian, a number of machine tool companies are fairly busy, but in some cases their operations will soon be pared unless fresh orders are received. Many companies expect to close the week of July 4 or later in the summer for a week's vacation with 40-hours' pay for employees. At Dayton, General Motors Divisions are running three days a week with about 60% of their normal force. National Cash Register is employing 80% of its force and works three days a week.

DETROIT — Machinery purchases are slim. Tool and die shops have the most work in months, but have ample capacity to take many more orders. The small tool business continues to gain slowly. Toledo reports a better feeling and a slight upturn in employment.

PITTSBURGH—Steel people are feeling more cheerful because of a contra-seasonal rise of a few points in mill operations and because of the belief that tonnage in the summer and early fall will be somewhat better than expected. A substantial number of small orders for rush delivery is proof that many users have exhausted inventories.

CLEVELAND — Machinery sales continue to shrink, though sizable foreign orders are in the offing. Auto parts factories are going along at about 10% less than the relatively poor rate in May. Steel production remains steady at slightly below the national average.

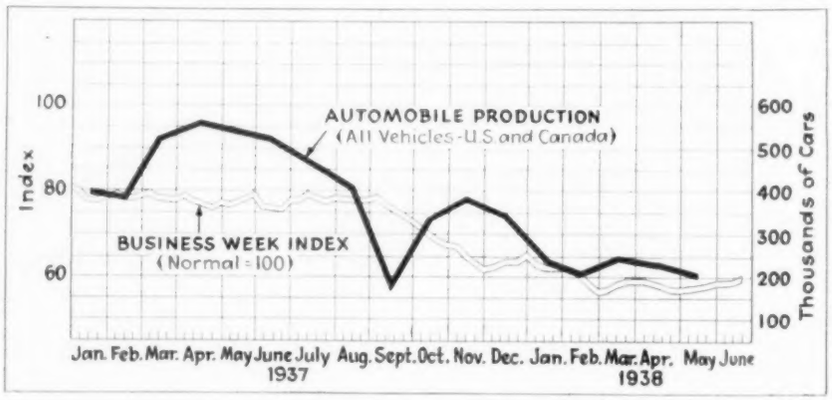
NEW YORK — Bethlehem Shipbuilding will not build new vessels at Morse drydock, acquired when United Shipyards was taken over. The Staten Island plant is equipped for construction, but no awards of new work have been made and no new machinery will be bought. Brooklyn Navy Yard will make some equipment purchases about July 15. The army is expected to buy machine tools soon. Germany has ordered several special machines from American manufacturers for the plant which will build the new low-priced, government-sponsored car.

SAN FRANCISCO—Airplane production is skimming along at close to full capacity with backlogs sufficient to keep operations at present levels for many months. Building construction compares favorably with that of a year ago. Machinery buying, however, is poor with closing of most inquiries being deferred.

CHICAGO — Farm equipment and tractor sales declined much faster than output during May and early June, the result being that dealers are heavily stocked and factories have large inventories of finished or semi-finished parts. Hence International Harvester will close its Milwaukee plant and its "Farmall" plant at Rock Island during July and perhaps longer. Other companies too are planning on drastic cuts in production. The steel trade is more buoyant because of a gain in small orders partly from automotive sources. Steadiest tonnage is in structural steel. Fairbanks Morse will enlarge activities at Beloit because of a large navy contract for Diesel engines. Coal stoker makers are working at capacity, estimating their year's business at 25% ahead of last year. Machinery inquiries are fairly good, but sales poor.

AUTOMOBILES VS. GENERAL BUSINESS

Car production was fairly steady in the first five months of the year, but will probably reach lower levels in the Summer months. Nevertheless, optimism for the future is growing in Detroit circles



AMERICAN MACHINIST

ESTABLISHED 1877

F. H. COLVIN • K. H. CONDIT • BURNHAM FINNEY, Editors

A look at

CHEVROLET'S RECORD

FROM WHATEVER ANGLE you look at it, Chevrolet's history is an amazing chapter in the annals of American industry. It is proof of what has been achieved—and what still can be accomplished—under the system of private initiative and enterprise in this country.

To go from "scratch" to a company with fifteen manufacturing plants, eleven assembly plants and annual sales valued at close to half a billion dollars within a period of 27 years is no mean achievement. In fact, it is a record that hardly a handful of companies has duplicated. Yet that is what Chevrolet has done.

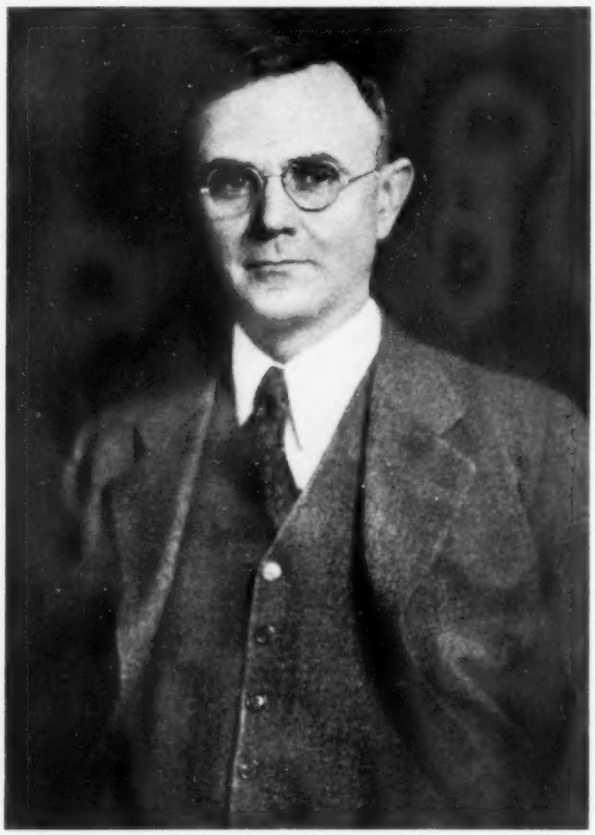
Go back, if you will, to a small experimental shop in Detroit in 1909 and see the feverish and enthusiastic experimental work on a new car going on under the guiding genius of Louis Chevrolet, famous in automobile racing circles. After two years had passed, during which four or five experimental cars were built, a car satisfactory for mass production was perfected. Thus on November 3, 1911, the Chevrolet Motor Company of Michigan was organized, a plant was leased on West Grand Boulevard in Detroit and production was started on a five-passenger touring model priced at $2,150 at the factory.

During its first seven years Chevrolet went ahead at a remarkable clip. It developed a nation-wide organization and set up a correlated system of production and distribution upon which its subsequent success has so largely rested. In 1913 it concentrated manufacture at Flint, for a time occupying the old Imperial Wheel plant on property now owned by Buick. When in 1914 it introduced its Baby Grand touring car and Royal Mail roadster (they had some pretty fancy car names in those days), the sales demand grew so rapidly that a branch assembly plant was rented in New York.

The same year a wholesale selling organization was started in Oakland, California. A year later offices were opened in Kansas City and Atlanta, being the first of the far-flung zone offices which now cover the United States.

1915 was a red-letter year for Chevrolet. Not only was the famous model 490 introduced, but additional production capacity was acquired. A plant at Tarrytown, New York, was purchased from the Maxwell Motor Company and arrangements were made for assembling facilities at St. Louis and at Oshawa, Ontario, Canada. The same year saw the incorporation of the Chevrolet Motor Company of Delaware which took over the man-

MARVIN E. COYLE has been president and general manager of Chevrolet since 1935. Born on a Pennsylvania farm, he early showed an interest in the mysteries and technique of accounting. He joined General Motors in 1911 about a month after Chevrolet was organized. During 21 years with Chevrolet he has been comptroller, assistant to the president, and vice-president and general manager. A year ago his outstanding ability was further recognized when General Motors elected him a vice-president and director of the corporation



CHARLES E. WETHERALD is vice-president and general manufacturing manager of Chevrolet. He began his automotive career with Buick 34 years ago when only two Buicks had been built. He became associated with Chevrolet in 1915, rose by successive stages to his present position to which he was appointed in 1931

agement of Chevrolet manufacture in all plants.

The following year brought further expansion. A new assembly plant was erected at Flint and others were started at Fort Worth, Texas, and at Oakland, California. The National Cycle Company and the National Motor Truck Company at Bay City, Michigan, were bought, thus adding small parts productive capacity. The Warner Gear Company's plant at Toledo, Ohio, was acquired; this gave Chevrolet transmission and gear capacity. A new axle plant was constructed at Flint.

This phenomenal growth—remember this was in the earlier days of the industry—was necessitated by a jump in production from less than 3000 units a year to more than 70,000 units by the end of 1916. Expansion did not stop, or even hesitate, but continued through 1917 during which the office building at 1764 Broadway, New York City, now the General Motors Building, was leased and

WILLIAM E. HOLLER, as vice-president and general sales manager, is responsible for all sales of Chevrolet cars and trucks. After occupying high posts with other automotive companies, he became associated with Chevrolet in 1925, climbed to his present position in the short span of eight years and is responsible for the current sales set-up

E. W. IVEY as general auditor of Chevrolet has charge of all of its financial affairs. He has spent his entire business life with General Motors or its divisions

the executive offices moved to it. Later it was purchased. Meanwhile production shot past the 100,000 mark; the count for 1917 was 125,882 units.

When Chevrolet became a part of General Motors in 1918, it embarked on another era of growth. A new assembly plant was built at St. Louis in 1919. Two years later the executive offices were transferred to the General Motors Building in Detroit, where they have been ever since.

Impetus was given to Chevrolet's rising fortunes when William S. Knudsen, as vice-president, took over the direction of operations in March, 1922. In truth, things happened fast and furiously under Mr. Knudsen, with the expert sales help of Richard H. Grant. In his first year Chevrolet took over from General Motors the former Central Products group comprising gear, axle and forge plants in Detroit. The Janesville, Wisconsin, factory of the Samson Tractor Company was secured and converted into another Chevrolet assembly plant. Construction of assembly plants was begun at Buffalo and at Norwood, Ohio. A sheet-metal plant was completed and placed in production at Flint in 1923.

Meanwhile production had soared. With the introduction of the Superior Models in 1922, output was nearly 250,000 cars a year. By 1925 the company was making over half a million cars annually and the Bloomfield, New Jersey, plant had been added for export operations. In 1926 the plant of General Motors Truck Corporation in Detroit was acquired for manufacture of front and rear axles. Experimental facilities were increased by the addition of a new building in Detroit's Hamtramck district. The gray iron foundry at Saginaw, Michigan, one of the two largest foundries in the world, was taken over in 1927.

1927 has a big ring around it for Chevrolet be-

cause it was then that output first crossed the million-a-year mark. And it should be added that Chevrolet has crossed that mark in five years since 1927, which is no small achievement in view of the long depression years through which the country has passed. Moreover, Chevrolet has led the industry in production and sales in eight out of the last eleven years.

But the story of Chevrolet's expansion must be completed. In 1928 an assembly plant was opened at Atlanta and construction was started on an additional assembly plant at Kansas City. A spring plant was built in Detroit in 1930, the year in which the Martin-Parry Corporation's commercial body fabricating plant at Indianapolis was bought.

In the Spring of 1935 a new assembly plant at Baltimore got into production. The same year new manufacturing plants were started at Saginaw, Muncie, Indiana, and Bay City, Michigan. Near the end of 1936 a new commercial body factory at Indianapolis, replacing the buildings acquired in 1930, was dedicated. Early in 1938 a new plant at Tonawanda, New York, for production of motors and axles began to operate, serving assembly plants at Tarrytown, Buffalo and Baltimore.

It was not until the early part of 1923, in its twelfth year of manufacture, that Chevrolet made its millionth car. In the ensuing fifteen years it has built and sold over twelve million cars, an average of about 800,000 units annually.

Chevrolet started out with a six-cylinder car. All models between 1914 and 1929, however, were powered by four-cylinder engines, with the exception of an eight-cylinder "chummy roadster" and touring car built in 1917, 1918 and 1919. Late in 1928 Chevrolet discontinued its four-cylinder models and introduced its six-cylinder International models powered by the Blue Flame valve-in-head engine. The company is still building sixes exclusively.

Chevrolet's leap ahead into top position in the industry has been accomplished under two men—Mr. Knudsen and Marvin E. Coyle. Mr. Knudsen was elevated from vice-president to president and general manager at the beginning of 1924 and served in that capacity until he was appointed executive vice-president of General Motors Corporation in October, 1933. He was succeeded by Mr. Coyle who had had long and honorable service as a first-rank official of the company. Since Mr. Coyle's accession Chevrolet has spent more than $75,000,000 on engineering and styling refinements and on plant expansions and plant modernization.

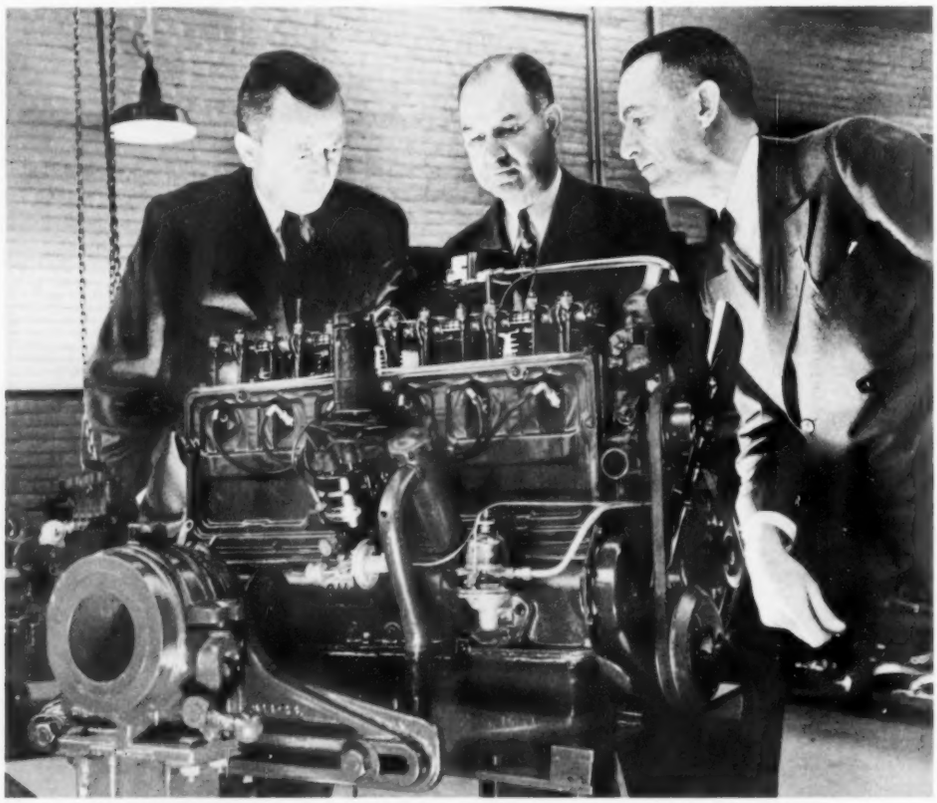
ED C. SHAW is general superintendent of all Chevrolet assembly plants. He linked up with General Motors 17 years ago, for nine years prior to assuming his present post was manager of a branch assembly plant, first at Kansas City and then at Oakland, California

DON P. O'KEEFE has been general purchasing agent of Chevrolet since 1921. He started as a clerk at Buick in 1906. He is one of the best-known purchasing officials in the automotive industry

HUGH DEAN is manager of Chevrolet manufacturing plants as assistant to Mr. Wetherald. He too is an old Buick man, having been appointed assistant production manager of Buick back in 1915. For many years he was associated in an executive capacity with Chevrolet's Detroit manufacturing plants

CLINTON R. SCHARFF holds the distinction of having joined Chevrolet in 1916 as traffic director and having remained in that post ever since

THE ENGINEERS



J. G. Wood, assistant chief engineer; J. M. Crawford, chief engineer; and P. A. Collins, chief experimental engineer, give a new engine the once over

WHERE IDEAS ARE ORGANIZED

CHEVROLET'S engineering organization is an independent body responsible for the performance and appearance of Chevrolet cars and trucks, but it relies on certain Corporation functions for advice and assistance. The engineers of the Corporation are available for consultation, and it is expected of them that they will act to steer the engineers of any of the various divisions away from glaring inconsistencies.

It is quite impossible to put one's finger on any date on the calendar and say that it marks the beginning of work on any particular model. Engineering development at Chevrolet is a continuing process. Projects of all sorts are constantly under way. As they are proposed they are entered in the project records, given serial numbers and assigned to different engineers for study. A glance at the record shows that some are speedily completed and the facts discovered made available for future models. Others are found to lead nowhere and are killed. Still others are either carried further or else postponed as not being applicable at the time.

As the organization chart shows, the major engineering functions—design, production and experimental — are kept separate, as are the minor functions listed. The engineering offices and drafting room are located in the annex to the General Motors Building in Detroit, where they are within easy reach of Corporation engineering, Research and the Art and Color Divisions. The latter activities are housed in the Research building just across the street from the Annex.

At each of the manufacturing plants there are resident production engineers whose job it is to smooth out difficulties that arise when designs go into production. They are empowered to modify designs that cause production snarls, but these changes must be checked back with the central engineering office if there is any question as to functioning or durability. Limits and tolerance arguments are fought out by these plant engineers. If limits are too close for existing equipment the design must be modified or else new machines must be purchased. Any such decision must naturally be reached in conjunction with the manufacturing chiefs. Changes of any sort depend to a large extent on how far along the tools are, because their cost is such a large factor in the production cost of an automobile.

All through the engineering organization runs the policy that holds a man to his job until he has trained

an understudy to take his place when promotion comes to him. In an institution as large as Chevrolet an engineer must accept the fact that promotion may be slower than in smaller companies, but to offset this he has the satisfaction that a good job awaits him eventually if he has the stuff. Employment is likely to be much more steady. Chevrolet is proud of the high percentage of its engineering staff which was carried through the last depression.

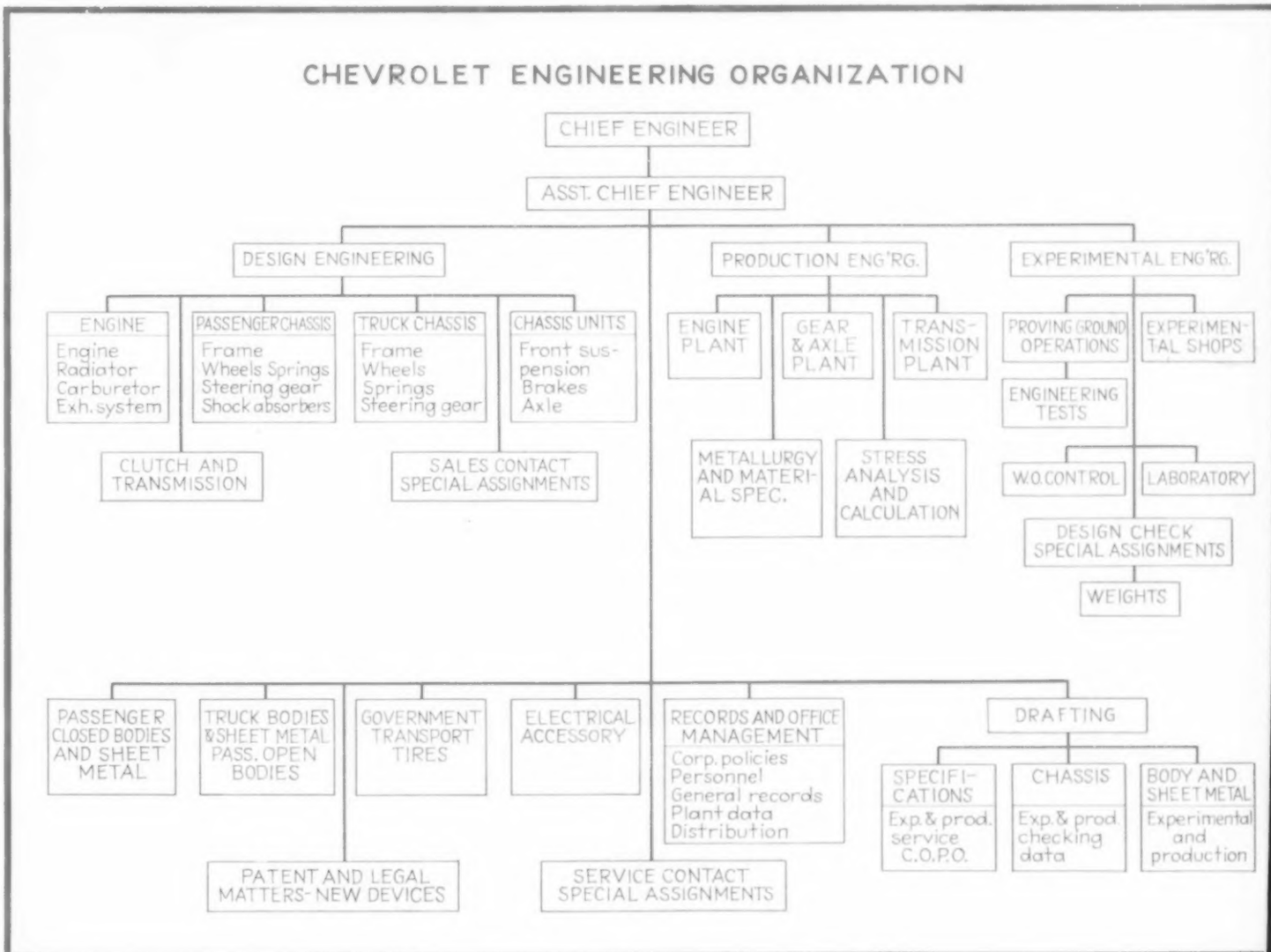
Chevrolet engineering offers opportunities both for experienced men and for beginners. Mature engineers are engaged when there is a place for them. Technical graduates start either in the experimental laboratory or at the proving ground. After gaining experience in both of these activities they are brought in and assigned to board layout work, from which they will be promoted to be project engineers as they show capacity. There is also an apprentice or student draftsman training course to which high school graduates may indenture themselves. This course lasts two years, is organized and administered by one of the checkers, and is supervised by the chief checker.

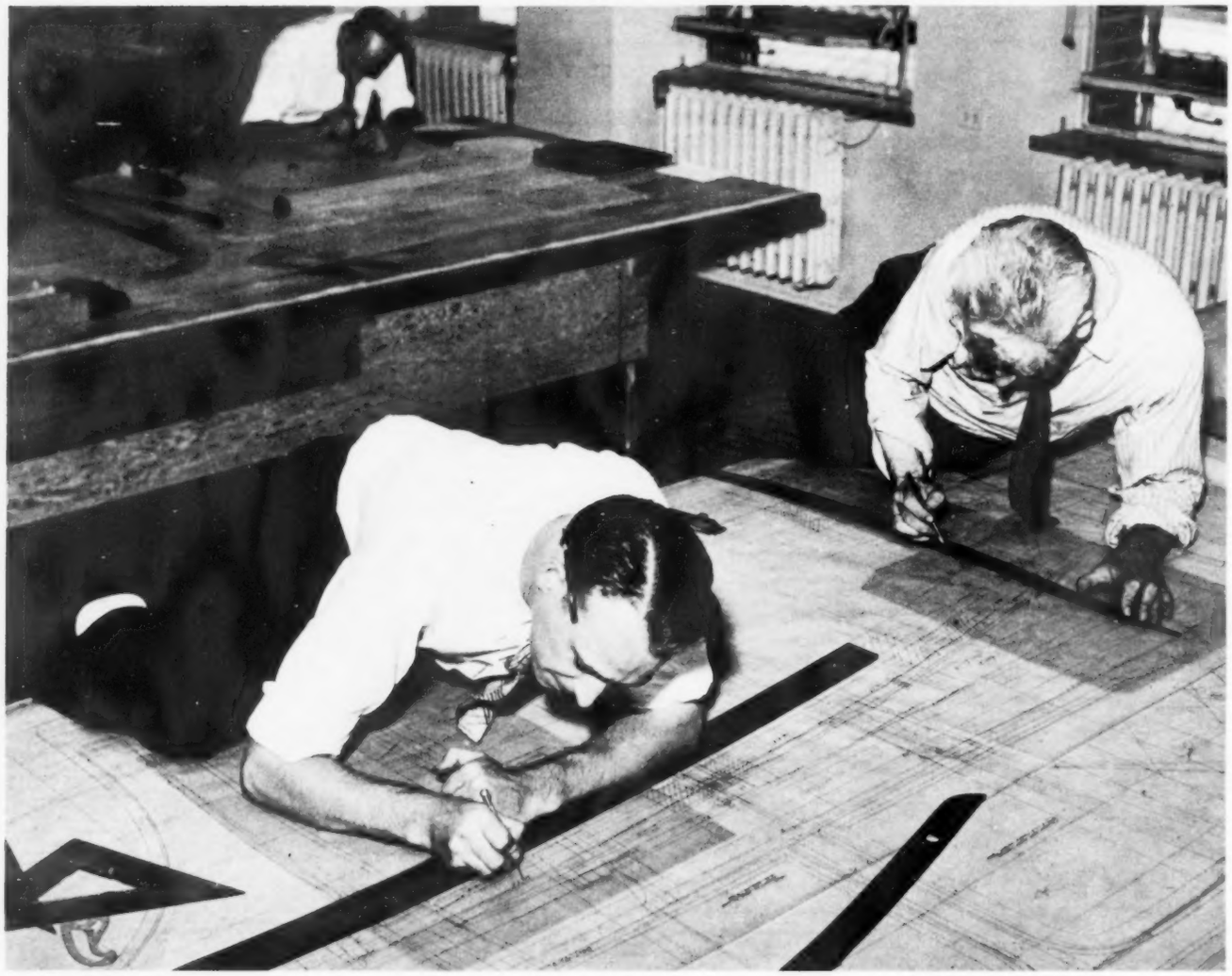
When the specifications of a new model have been decided upon and the details worked by the designers, experimental models are built in the experimental shops. In the meantime, the "package" or exterior treatment for the mechanism and the passengers or load it is to carry has been developed in the Art and Color Division of the Corporation. The work in this section and in the experimental shop will be described on subsequent pages.

Each fall several of these test cars, which will become the production model a year later, are driven out to the General Motors Laboratory at Phoenix, Arizona, by a crew led either by the chief engineer or his assistant. These cars will differ in detail so that alternative constructions of various units can be road tested and compared. All sorts of roads and climatic conditions are encountered before these cars get back to Detroit. Further tests are made, on them and on the units that make them up, at the General Motors Proving Ground and in the Chevrolet laboratory of which more later.

In the spring revised models are taken on a similar trip to Phoenix for final checking. On this trip final checks are made on spring rates, shock absorber valving, ride control, spark advance curves, etc. Although details of these models have been released for tooling at this stage, minor changes are still possible if the tests show them to be necessary. These spring models are hand built from the same drawings that will be released to production.

CHEVROLET ENGINEERING ORGANIZATION





Draftsmen work out curves for the body and fender dies from measurements taken on the accepted wooden model

Various metal parts for the sample models are made in the division's metal shop

STYLING THE PRODUCT

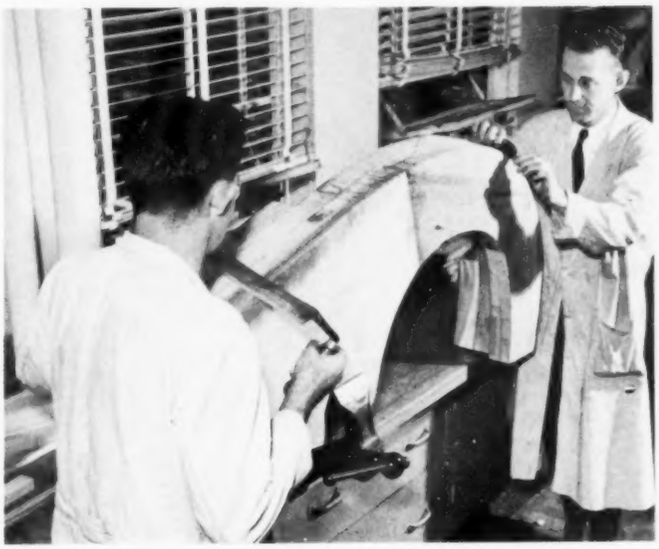
JUST ABOUT the time this number of *American Machinist* reaches your desk the Art and Color Division of General Motors will be starting work on the 1940 model for the various car divisions. This division has grown in eleven years from one man to 300, and in that time has established its own precedents and procedures and a corps of experts in design, color, form and technique that is without parallel.

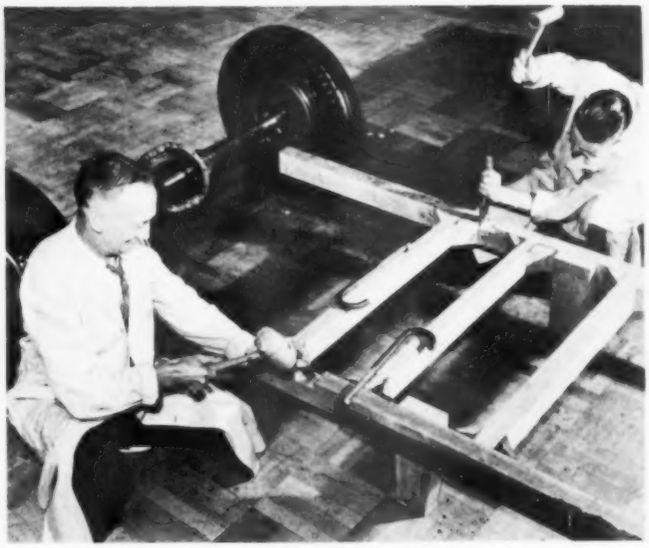
In its early days the division worked indiscriminately on all the cars built by General Motors, but the inevitable result was a family resemblance that was not entirely desirable. Today the men working on Chevrolet models are rigidly excluded from the departments where models for other Corporation cars are in process, and vice versa.

From Chevrolet's chief engineer come the specifications for wheelbase and chassis height. Then the package size must be developed by determining headroom for the passengers, the spacing of the seats, and the location of the engine. Next, such details as pillar widths, window openings, relation of windshield opening to eye level, trunk capacity, spare tire location, are studied and established tentatively.

A wooden "trim buck" is now made up in the wood shop, and seats are put in it to check window spacing, etc. The car is really designed from the inside out. With the body dimensions set and the various openings decided upon the body lines can now be studied.

Simultaneously another group has been working on the front end de-

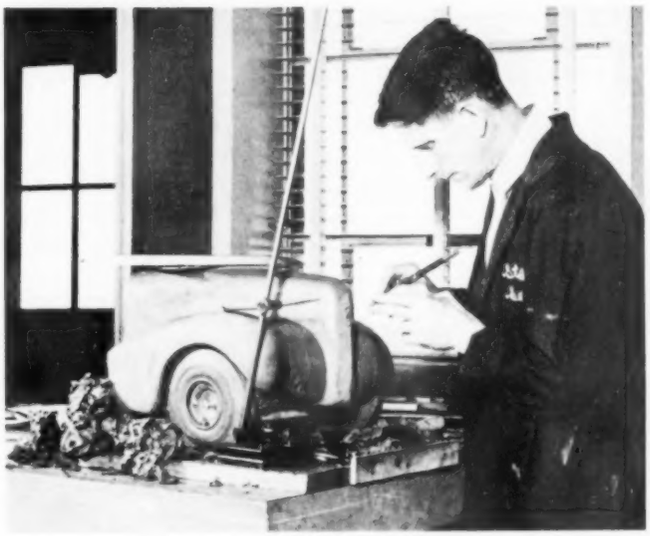


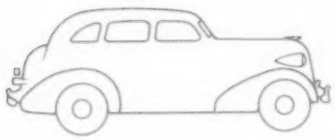


This will be a wooden fender when it's done but it will look like a real one

A wooden chassis is entirely adequate for the hand made model body

Artist at work on a quarter-scale plaster model of a front end





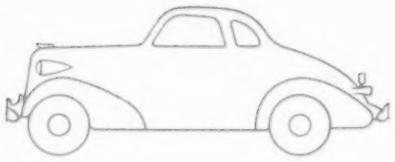
sign. A "front end buck" is made up of wood and covered with modeling clay so that form can be worked out. Grilles and louvres may be made of wood and covered with silver foil to simulate bright metal in the finished car. The chances are that several alternative front ends will be worked up to attach to the body model to see which harmonizes best. The chosen combination is then smoothed up and lacquered to look like a finished job, and the accessories, which have been carried through by a third group are attached.

The next step is to build a wooden model from the plaster one. Draftsmen measure up the body curves and lay out templets for the sheet-metal units. The bright parts are made up in the metal shop and plated. A wooden chassis is built and fitted with steel axles. Wheels from the current model, or new ones, are mounted. The doors are hinged and glazed, and the instrument board is installed. The job

Finishing touches on a plaster body model

New colors at the rate of six a month are added to the more than 2,600 on this board

Each month the automobile color preferences of the country are mapped



is trimmed and lacquered and is ready for criticism. After the Chevrolet officials are satisfied the new model must pass the critical inspection of the Corporation Product Committee, made up of the top executives.

Most of the designers of the Art and Color Division have a good working knowledge of the shop processes used in producing the parts they design. They are creative artists, but practical ones at the same time. They work in close cooperation with the Fisher Body Division staff which is concerned with engineering, fabrication and manufacturing problems.

All during the period when the new body models are in process, the color problem is being studied. The Color Service of the Division has at its disposal some 2,600 colors, and is adding about six new ones each month. Selection of color combinations is based on the color sales map shown in one of the illustrations. This map is brought up to date each month. It shows color preference of customers broken down by states and by every Chevrolet sales zone in the United States.

Although the foregoing statements have been based on passenger car designs, they apply equally to the design of Chevrolet trucks, and trucks built by other divisions. There is a separate section concentrating on truck design. In some ways it handles more complicated problems than the passenger car section. After all, there are many more types of truck bodies than there are passenger bodies, and every one of them has to be worked out with care, even though not so many of each type will be built.

MODELS MADE BY HAND

AUTOMOBILE manufacturing has become so symbolic of mass production in the public mind that it would surprise most people to know that there is a shop in Detroit where automobiles are built one at a time by hand. This shop is the Chevrolet experimental shop, and it is really 22 shops under one not very large roof.

Here the experimental cars mentioned on a previous page are built for the engineering department. The normal force is around 200, and the men are craftsmen, for the most part. They are accustomed to handle peak loads and rush jobs because that is the basis on which much experimental work has to be done. In between times they build gages, inspection equipment and special tools for use in the shop and adjacent laboratory.

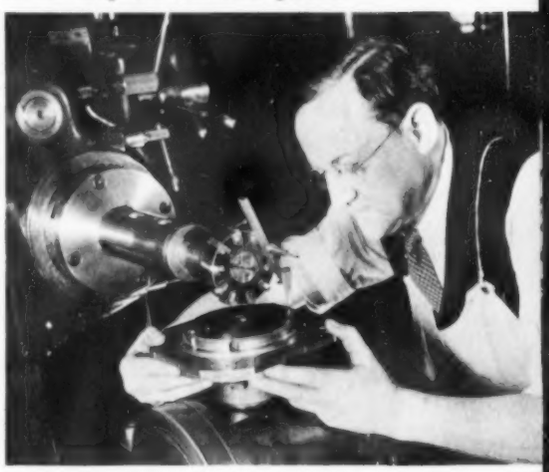
Every job that comes into the experimental shop is on a work order. There may be as many as 800 jobs in the shop at a time, and the order of priority is likely to be changed daily.

Equipment is what you would expect in such a shop — engine lathes, milling machines, upright and radial drills, grinders, horizontal boring machines, two or three presses and welding machines—few of them new but all of them in good shape. In short, everything needed to build every part of an automobile or truck from wheels to water pump, is here, and men who know how to use it.

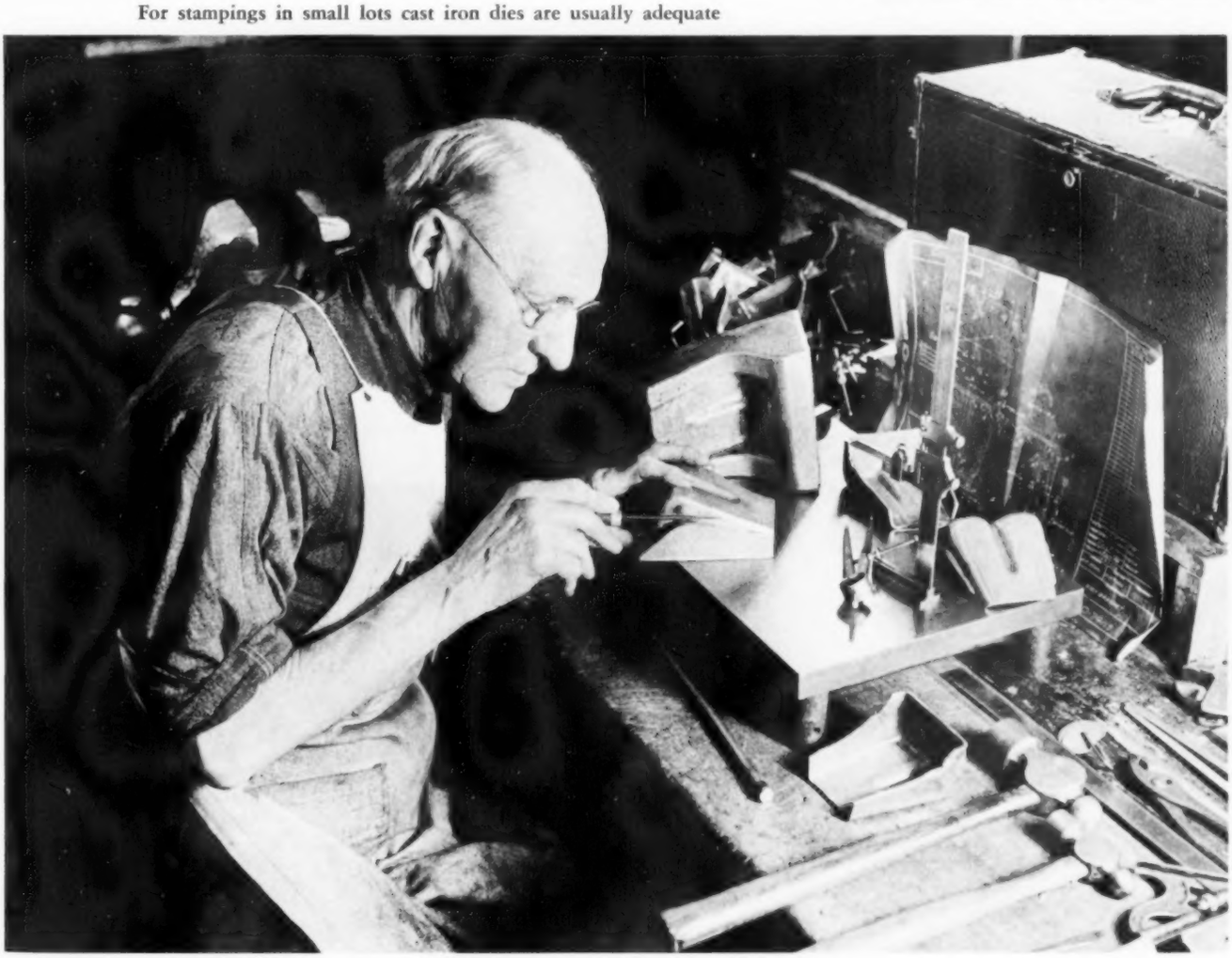
Counterpart of Regular Run

The experimental shop has no foundry, but it does make the patterns for the few castings it needs. It has a blacksmith and a heat-treating department. It makes the punches and dies for its sheet-metal parts, thick or thin. These parts are drawn from sheet stock in temporary dies, not hammered out. The object is to have drawn parts in the experimental job so that the performance of every part may be

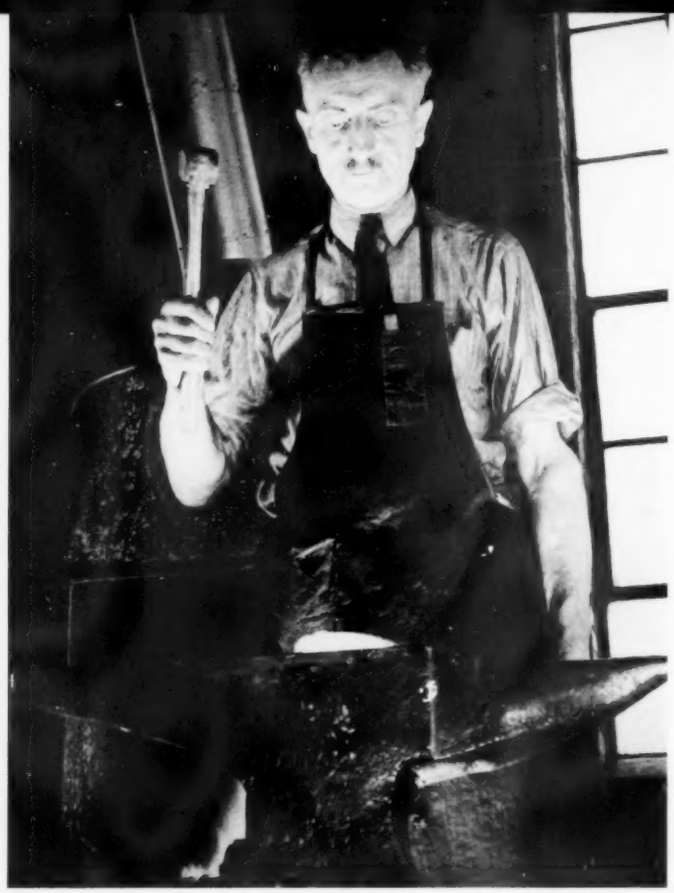
Indicators like this one are made in the shop between rush periods



For stampings in small lots cast iron dies are usually adequate



Forgings for experimental models are made by the time-tried method of hammer and anvil



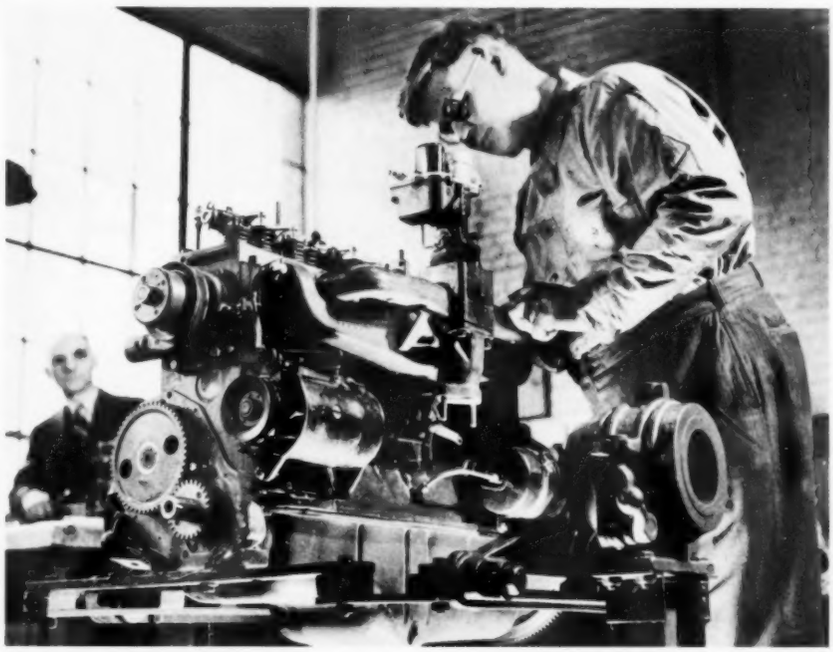
Inspection is done on a small-lot basis with many of the fixtures built as fill-in jobs

as nearly possible like its counterpart in the production car.

These dies are made of cast iron, hard wood or welded steel depending on the service required of them, and always remembering that the piece is the objective and not the tool. As a consequence of this policy some of the tools would never be recognized in a self-respecting tool room, but they do their work which may be to produce one piece or 50, not more. The work

Many new parts are turned out by tool-room methods as in this lathe set-up

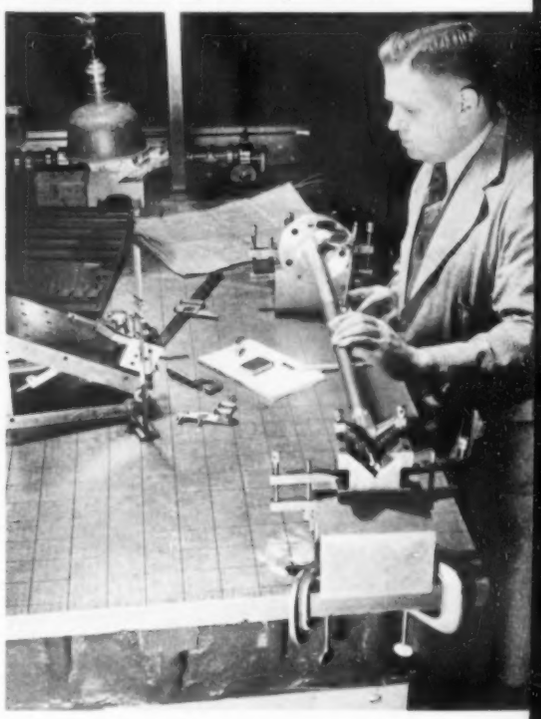
Every model car is checked to see that it accords with the original design



Finishing touches are put on an experimental motor in the motor checking department

Set-up in V-blocks on an improvised fixture, an experimental axle shaft is indicated for accuracy

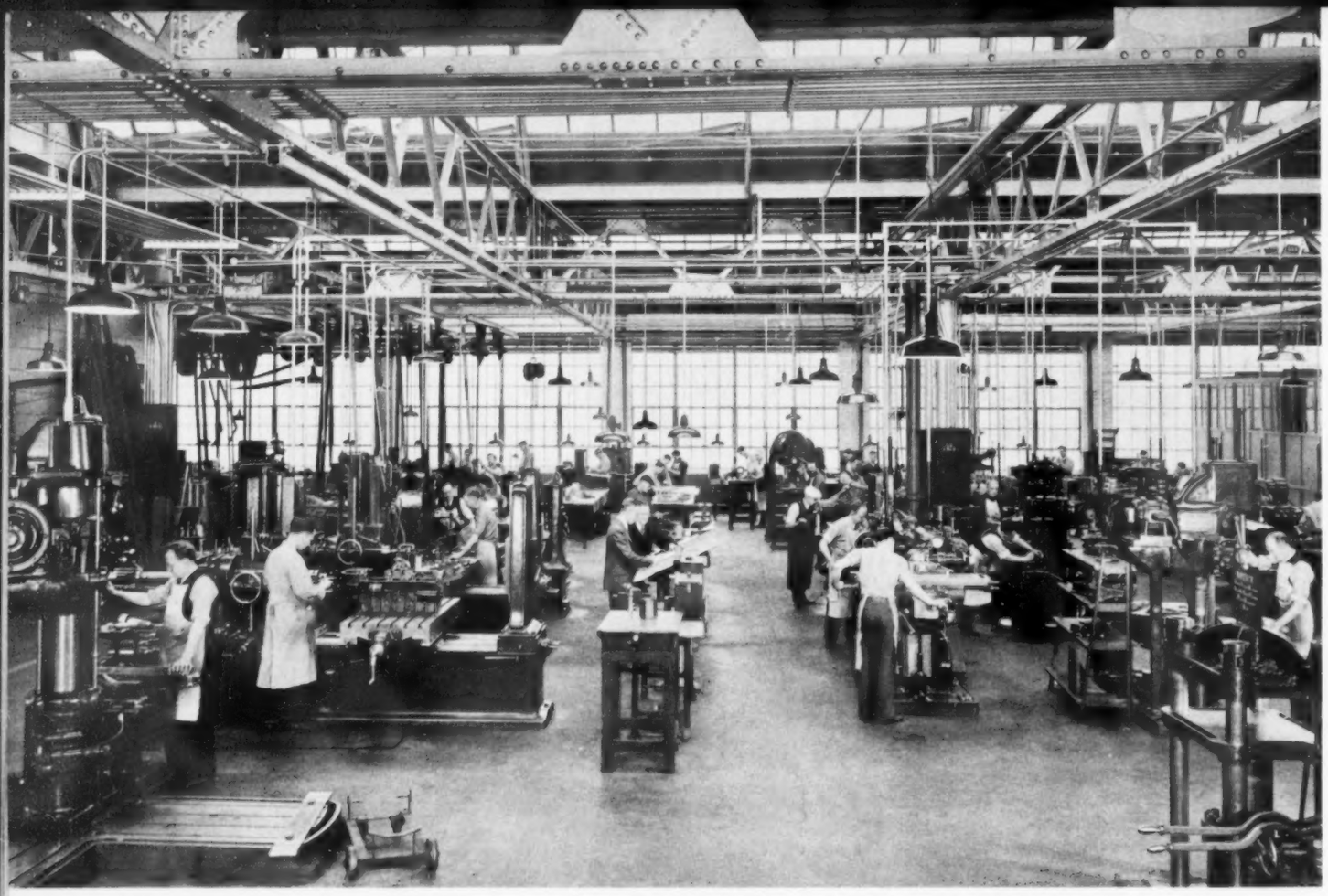
Some of these wooden models will serve as masters for the die-sinking machines



produced on these tools is not as smooth as work turned out of production tools, but it is seldom necessary to do any subsequent cleaning up. Furthermore, it is seldom necessary to keep them very long because they are used only on experimental jobs and become obsolete very quickly.

Fenders are about the only parts not made as production parts are made. The expense of dies for drawing a complete fender would be prohibitive. They are worked out in halves and welded together, but this is not evident after they have been smoothed up and lacquered.

Stock production parts that can be used are ordered in as needed and kept in a conventional stock room. All parts used in the experimental



Well lighted, well equipped, well staffed, the model shop can and does make every part of an experimental car

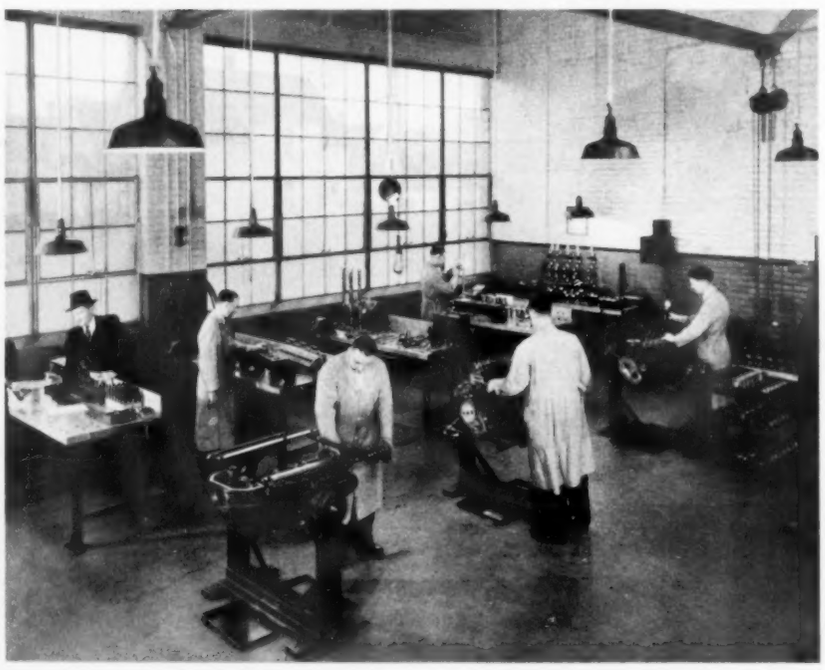
cars, no matter where they come from, are carefully inspected, checked and weighed. Since modern motor car design is a constant battle against weight this last point is important. In addition, so-called "pirate parts", made by outside companies to undersell service parts, are inspected and checked to see just how far they are below standard.

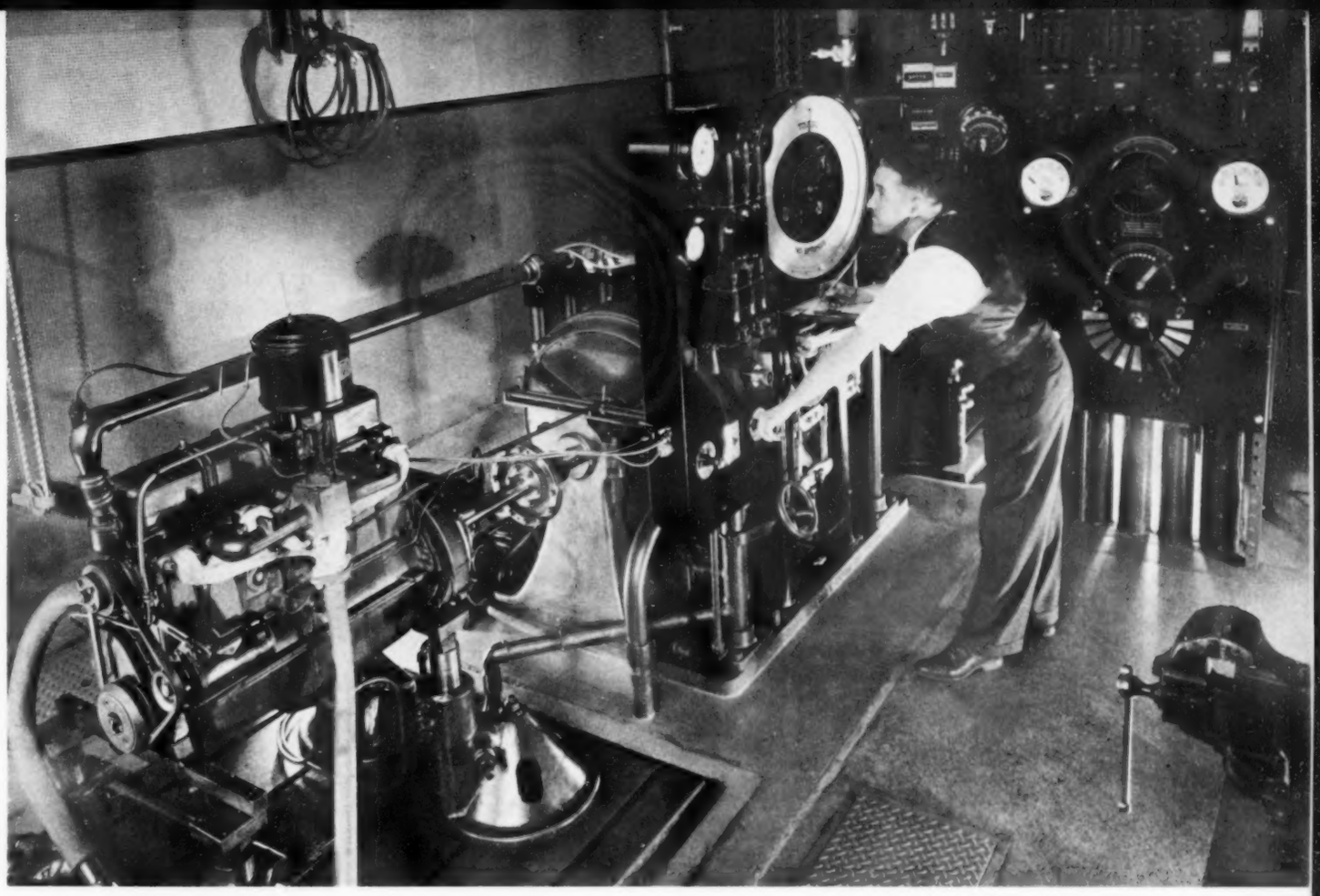
And Double Check

An elaborate checking system has been installed in the motor assembly room. Every part subject to wear is measured and its dimensions recorded before a car leaves for the Proving Grounds or for laboratory or road testing. It is re-checked when it comes back and any differences recorded. The routine involved seems tedious, but it is unavoidable if reliable test results are to be had.

Completed experimental models of cars and trucks are measured on the large surface plate to make sure that the whole job is as designed. The reputation of more than one engineer has been saved by the experimental shop which has discovered errors before they got far enough to do any harm or cost much money. That is one of the things an experimental shop is for and one that has saved its cost many times over.

Every part of every experimental engine is measured carefully before and after test runs





There isn't much you don't know about an engine after it has been tested on this electric dynamometer in a sound insulated room well fitted with instruments

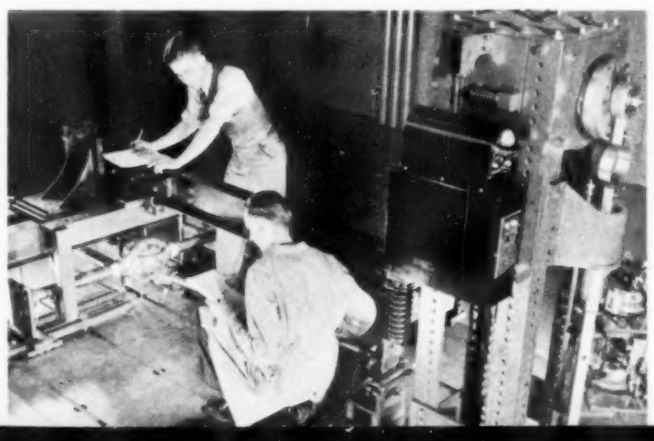
TELLTALE TESTS

ADJACENT to the experimental shop on which it depends for considerable service is Chevrolet's new experimental laboratory. It is equipped with a set of chassis rolls on which either front or rear wheels of a car can be rotated to simulate road conditions. Cleats on the wheels give the effect of rough roads — exaggerated, if necessary. A large pit equipped with flood lights facilitates inspection of the lower part of the chassis while it is under test.

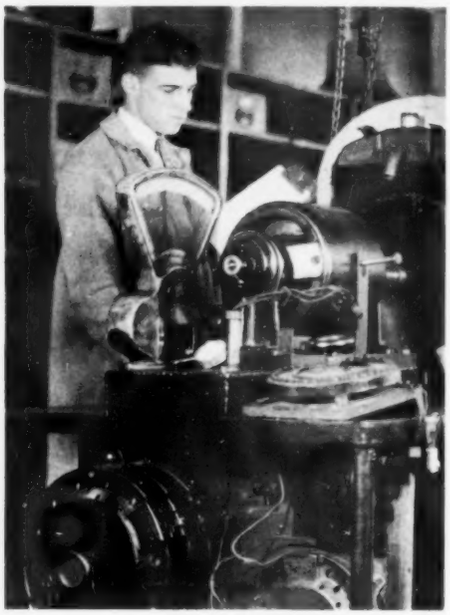
Five engine test rooms contain electric dynamometers, two have water brakes. The carburetor flow room has adequate apparatus for development and test work. Temperature noise and humidity are under control. Another room contains apparatus for testing electrical equipment, and still another has two electric dynamometers for the high-speed testing of fans and water pumps.

The physical test room houses a 100,000-lb. universal testing machine and various machines, many of them made in the experimental shop, for accelerated testing of chassis parts. There are benches for small part testing and four "stroking" machines for accelerated testing of diaphragm clutch springs, rubber engine mountings, third member assemblies and the like. These machines are mounted on a floor surface plate 75 ft. long by 7½ ft. wide, made up of ten cast alloy iron plates weighing 28 tons.

Hydraulic brake hose has to stand up; this is only one of the many tests applied



Two young engineers give a rear axle the works



A special machine for testing car parts in the research laboratories

RESEARCH FOR RESULTS

THROUGH its chief engineer, Chevrolet maintains close contact with General Motors Research. He sits on the technical committee of the corporation together with the chief engineers of the other divisions. If the division wants consulting engineering advice which the research staff can supply it pays for it at cost on the theory that it would have to foot the bill no matter where the job was done. This function of General Motors Research is handled much like commercial consulting service. It represents perhaps 40 per cent of the activity of this group.

Another 40 percent of the work done by Research may be classed as product development. This work is essentially long-range work as contrasted with the development in a car division which has to meet a definite date each year. When such products reach the working model stage, they are turned over to whichever division is in a position to commercialize them. No charge is made for such development work because it has already been charged as research expense. The products thus developed are publicized to the divisions through a monthly bulletin and through the personal contacts between men in Research and others in the division engineering departments.

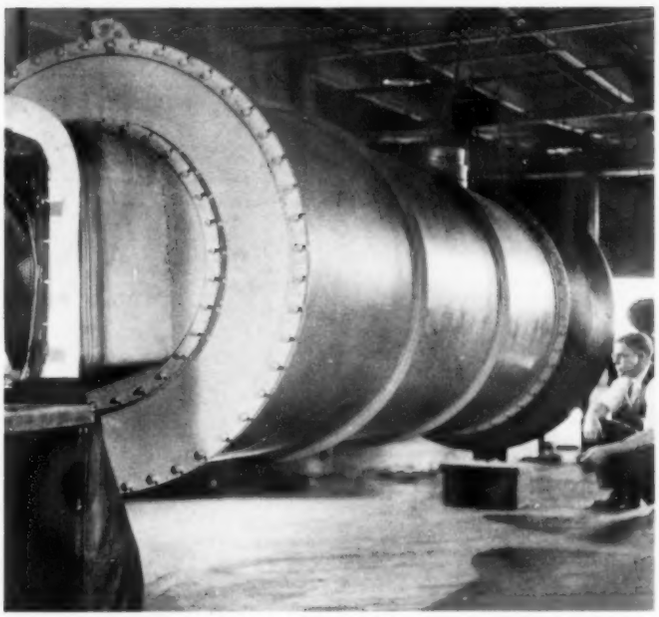
The remaining 20 per cent of the research activity is devoted to basic science. It might be likened to insurance on a property as contrasted with fire fighting because it looks to the far future when current products of the corporation may have been succeeded by something very different.

Aside from the contacts made through the technical committee, Research organization and service to the divisions is as loose and flexible as possible. Every department of the laboratories has some sort of an informal tie-up with individuals in divisions that might have any interest in the work of that department. It has been particularly effective where oils and finishes are concerned.

With two exceptions Research pays no attention to production equipment or production problems. These exceptions are the laboratory shop where General Motors dynamic balancing machines are built for all divisions, and the department where most of the carbide-tipped tools used in Corporation plants are finished. Both are the outcome of research work done in the laboratory, and each has remained there because it seemed more economical to handle them that way than to transfer them to the divisions which would involve breaking them up.

The Research Division maintains a 15,000-volume technical reference library for the benefit of all divisions. Bound volumes of technical periodicals are always on file. Loan arrangements have been made with other libraries to facilitate the exchange of volumes needed that are not universally available.

One function of this division which is not generally known is the selec-



The research chemist works on fuels and lubricants for the benefit of all divisions

Engineers finding out with the help of a wind tunnel how much a fan will blow

tion and training of engineers for other divisions. The personnel director scouts the technical schools each year and picks undergraduates for summer jobs, usually between the junior and senior years. Some of the boys from the General Motors Institute at Flint are also included. The shops, laboratories and drafting rooms of the division provide excellent facilities for giving the boys a varied short training and for studying them to determine their potentialities. Those that show real promise are offered permanent positions on completion of their college courses. As they acquire experience they are transferred to the division having a need for them.

An unusual case of transfer of personnel occurred when the diesel engine project reached the commercial stage. So many of the men connected with it were deemed so indispensable to its further development that they were moved over almost as a unit to the new diesel engine plant.

General Motors Research is a living proof of the theory that a research laboratory will pay if you pick good problems for it to solve.

HOW STANDARDS ARE SET

As a division of the General Motors Corporation, Chevrolet participates in the formulation of standards through its representatives on the four interdivisional standardization committees. These four committees deal with (1) metallurgical standards; (2) tool standards; (3) engineering standards; (4) non-productive material standards. In addition to agreeing on standards, these committees serve as a valuable medium for the interchange of ideas between the divisions.

Members of these committees are appointed by the division managers but the membership is limited by the Corporation to the car divisions and a few of the accessory divisions to keep them from getting to be too large and unwieldy. Other divisions have contact members who are asked to attend meetings when they are needed. The regular members meet at infrequent intervals as enough work piles up to warrant action.

Committee 1, although it is known as the metallurgical committee and is made up of division metallurgists and experts from the Research Corporation, takes care of all production materials, metallic and non-metallic. Its specialists represent it on outside technical committees, each in his own field.

Committee 2 is made up of the small tool supervisors of the divisions. Its secretary, who is also secretary of Committees 3 and 4, represents it in outside standardizing bodies, but reports back all proposals and projects to the committee for approval. As its name implies, this committee is concerned with reducing the number of sizes and types of cutting tools, tool bits, twist drills, and the like in the interest of economy and simplification.

Committee 3 has developed interdivisional engineering procedure and maintains the standards records. It devised the part numbering system in vogue in all divisions. Under this system each division has its own block of numbers for parts peculiar of its product. If a part used in one division can be adopted by another, the part number remains the same no matter where it is used. Such car parts as bolts, nuts, rivets, fan belts and oil fittings have been highly standardized.

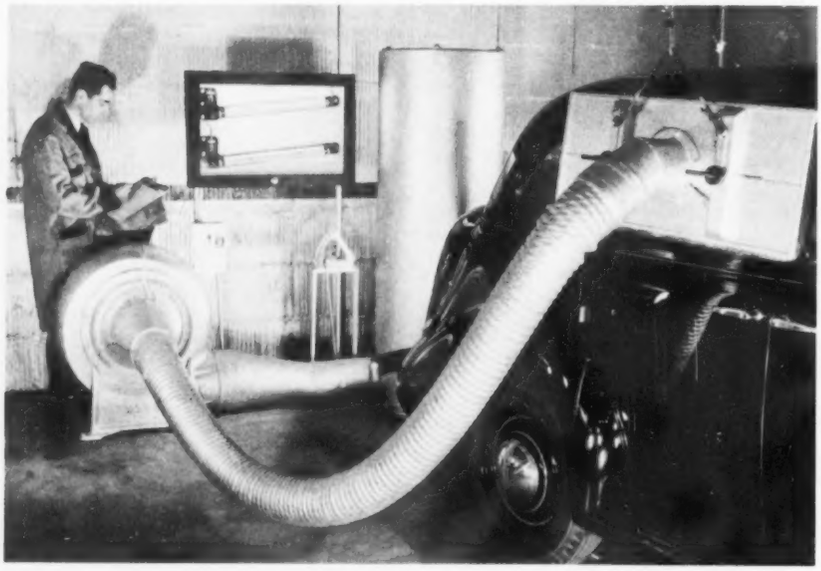
Committee 4 deals with such non-productive materials as gloves, cleaners, chemicals, etc.

Drawings of standard parts are made in the standards office and Van Dyke prints are supplied to the divisions as wanted. All typing of the standards and specifications is also done here and reproduced for distribution by the offset process.

The General Motors standards, now assembled in four volumes, are widely known and used. In fact, some companies have adopted them bodily. Some 200 sheets are added or replaced every year. The divisions are not charged for these books, but outsiders who want them are required to pay for them.

In addition to the cooperative standardization program in which a division participates, it carries on certain work of its own; for example, the machinability tests at the Chevrolet Gear & Axle Plant. The results of such investigations are made available to other divisions through lectures, reports and conferences.

General Motors Proving Grounds from the air



This piece of apparatus will measure gasoline consumption to the drop

A rig to measure how hard you have to pull to steer an automobile

How much air does a body leak? This giant vacuum cleaner tells exactly

GROUNDS FOR PROOF

AT THE General Motors Proving Grounds new models are given every kind of road test that ingenuity can devise. The regular staff checks the performance of every make of car, domestic and foreign. Chevrolet's own test crew, which has its own garage and shop at the Proving Grounds, works exclusively on Chevrolet cars, giving new constructions a thorough trying out before they are released to production.

DISTRIBUTION

QUALITY DEALERS

MATCHING the performance of the engineering and manufacturing divisions of Chevrolet is the fine record of the sales division in selling Chevrolet cars. The fact that Chevrolet has led the industry in sales during four out of the last five years is no happenstance. It is the result of a carefully planned program conceived and carried out by William E. Holler, general sales manager.

Until Chevrolet instituted its so-called "quality dealer" program, the automobile industry had gone on the theory that the more retail outlets established, the larger the sales volume. Chevrolet exploded that theory. It scientifically determined by means of intensive surveys how much potential business there was in a given territory and then assigned just enough dealers to handle the volume at a good profit. "Cross-selling" or overlapping of sales territories was discouraged so that two or more dealers would not battle for the same order.

The process was one of eliminating the ineffectual dealer in favor of those who demonstrated beyond doubt their ability to merchandise Chevrolet cars intelligently and profitably. The consequence is that Chevrolet today has 500 fewer dealers than it did when Mr. Holler inaugurated his plan in 1935, but the present selling organization is more capable of handling the company's big sales volume than the former larger group of dealers. Moreover, while automobile dealers generally have been complaining about losing money, Chevrolet dealers have made liberal profits.

Chevrolet's merchandising program goes much farther than a culling of the good dealers from the bad. It has set up a democratic system whereby its dealers are given a voice in the sales management and whereby dealers and Chevrolet's sales executives can get a clearer understanding of each other's problems.

In January, 1937, the company founded national dealer planning and national dealer used car organizations which have their roots in the 45 zones and nine regions throughout the country. Each zone manager appoints ten dealers in his territory to serve for six months on a zone dealer used car committee and ten others to serve a similar time on a zone dealer planning committee. Dealers of all classes are selected: big and little, and from small towns as well as large cities.

The two committees meet monthly and discuss whatever subjects they may choose pertaining to their own businesses and to relationship with the factory. The zone dealer planning committee, for instance, usually talks over retail selling, truck merchandising, advertising, and the sale of parts.

Chairmanship of the committees is rotated monthly; the zone manager sits on the sidelines, ready to help if asked. There is no formal program at the meetings. Instead an attempt is made to keep the gatherings in the nature of a roundtable discussion.

Stemming from the zone committees are regional committees, one concerned with dealer planning and the other with used cars. The regional dealer planning committee consists of the chairmen of the zone committees (elected monthly), and the regional dealer used car committee of the chairmen of the zone dealer used car committees. The regional committees also meet monthly.

Regional chairmen, who are elected once a month, assemble every thirty days at Chevrolet's home office in Detroit. After talking over factory-dealer matters, they make recommendations to the management which they believe will be helpful to dealers and Chevrolet alike. The system of rotating chairmanships all along the line makes it so that all committeemen, at one time or another, serve on one of the national committees.

The story of Chevrolet's merchandising and dealer-relationship program doesn't end with the quality dealer plan and the national dealer committees. A full recital must take into account the system for adjusting promptly consumer complaints, the training of dealer service men and service managers, the creation of a separate used car selling organization to assist dealers in handling used cars, and the dealer planning and distribution committee which functions constantly with five representatives of General Motors having an equal vote with the Chevrolet management in formulating broad policies.

Chevrolet's complete used car selling organization for the first time in the history of the automobile industry parallels the new car merchandising organization. It consists of two assistant general sales managers, one to supervise the eastern division and the other the western division, and nine assistant regional managers to head up the field work. An assistant zone manager in each of the company's 45 zones is assigned the task of carrying used car plans and merchandising ideas directly to the dealers and their staffs. The used car sales set-up goes still farther in that the responsibility for proper and efficient handling of used cars is broken down in each dealership. The entire used car program is under the supervision of Mr. Holler.

National dealer planning committee meets monthly at Detroit

MANUFACTURE

INTERPLANT COORDINATION

CONTROL of Chevrolet manufacturing and assembly centers in the office of the vice-president and general manufacturing manager in Detroit. Assisting him are the manufacturing manager and the assembly manager, both of whom have offices in Detroit, but who spend most of their time visiting the plants under their general supervision.

The manufacturing manager flies each week to the Tonawanda plant and to the Muncie plant. The Detroit plants are within two miles of the office and are therefore easy of access. The plants at Flint and Bay City are reached by automobile each week. The assembly manager, whose plants are not nearly so accessible to Detroit as the manufacturing plants, naturally is not able to visit them as often.

Operations of assembly plants are controlled largely from Detroit but each manufacturing plant manager operates a generally autonomous unit. Hours, wages and schedules are controlled from Detroit and material control is also centralized there. Releases of parts from the manufacturing plants to the assembly plants and from outside suppliers to the assembly plants are handled in the Detroit office.

The manufacturing manager has one expert assistant on the machine operations and another on sheet-metal operations. He and his assistants act as advisers to the plant managers who are held responsible for their own plants. The two assistants to the manufacturing manager are former plant managers who have been promoted.

Actual buying of materials and parts for each plant is done by the plant purchasing agent on authority issued from Detroit. Each manufacturing plant handles its own layout with its own layout experts and purchases its own tools and equipment. Detroit does not interfere with the master mechanic who is the local equipment man in each plant.

Generally speaking, replacements of production equipment that will pay for themselves in two years are practically automatic. A car part change that demands new equipment for its manufacture will be approved if the equipment involved will pay for itself within six months, even if it must be scrapped after that. In decisions such as this, and also where special equipment or machinery involving sums of $100,000 or more are at stake, the Detroit office sits in. Such expenditures are checked very closely.

Burden control for each fiscal year is established by the Detroit office and is divided into fixed and variable items, each of which is allocated by per cent to each of the component costs. This burden control schedule varies somewhat from plant to plant, but not in any material way. It is discussed with each plant manager individually to make sure that he understands the allocation and concurs in the percentages assigned.

Plant managers meet each year in Detroit to discuss questions of company policy and of mutual interest. If a major change in company policy is to be made the managers will be called in for a special meeting at that time.

The strength and weakness of each individual manager is well known in the central office which stands ready at all times to give him assistance of the kind he needs. In this connection the Detroit office reserves the right to transfer subordinates from one plant to another when it becomes necessary to strengthen a particular staff.

Operations Are Decentralized

As should be obvious, Chevrolet manufacturing is decentralized to a considerable extent. This is in line with the corporation policy of maintaining active industrial enterprises in as many communities in the country as wisdom dictates. In case of a major disaster of any sort to a particular manufacturing plant, some other plant can carry the load temporarily or else the parts produced in that plant can be secured from outside suppliers. The new Tonawanda plant, for instance, turns out the same sort of product that comes from the Flint and Detroit plants. Products of this plant will in general be shipped to the Baltimore and Tarrytown assembly plants and to the Bloomfield export plant, in order to keep freight rates at a minimum. Other assembly plants are supplied from Flint and Detroit.

The Chevrolet organization operates two apprentice schools; one in Detroit, the other in Flint. Sixty boys are in the Detroit school and 80 are in training at Flint. These boys are given a thorough four-year training and are then assigned to whichever manufacturing plant has use for them. They are encouraged to take night-school work during and after their apprenticeship training and most of them do.

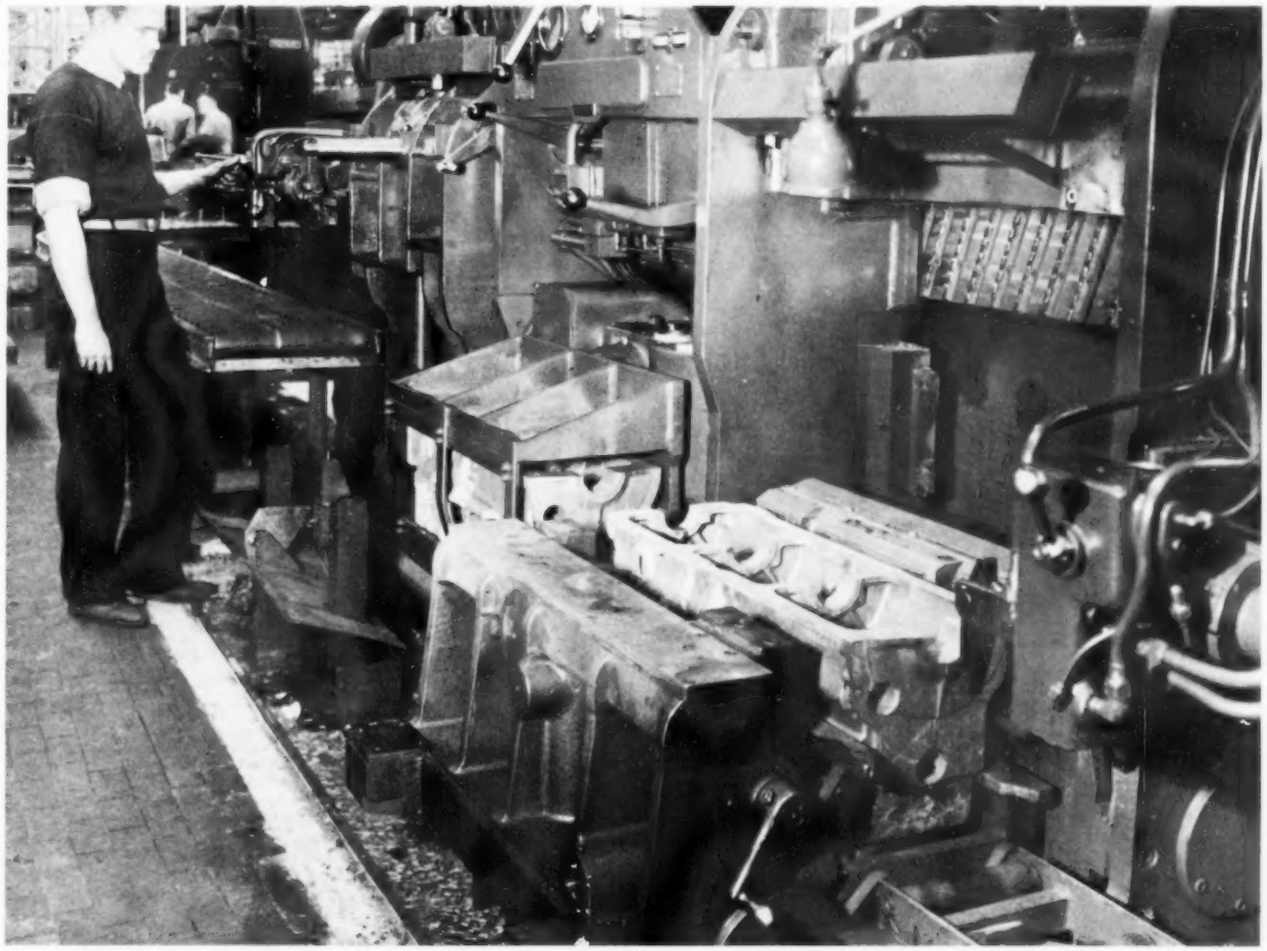
In addition to the boys from the apprentice courses, Chevrolet takes on approximately 40 boys each year from the General Motors Institute at Flint where promising young men are given cooperative training alternating between shop and classroom.

In addition the supervisory force is recruited from selected graduates of good engineering schools. Twelve boys are selected each year and put through a four-year training period at the Detroit and Flint plants. In addition eight more are taken on at the Muncie plant each year.

These men are started at an 80-cent-an-hour rate because their technical training is assumed to be about the equivalent of four years in the shop. The manufacturing manager takes a keen interest in these young college trained engineers and personally visits several approved engineering schools to make his selection each year. The records of these specially selected recruits have been decidedly satisfactory to the Chevrolet officials.

From the foregoing it will be obvious that the central manufacturing office of Chevrolet in Detroit is well organized to control the extensive manufacturing operations of the division. Furthermore it should be clear that steps are being taken to maintain the quality of the supervisory group on which this control depends.

THE ENGINE



The block at the right is in the loading position. It is swung upward and pivoted 90 degrees so the pan face can be broached. The cutter seen at this station is not for this operation but is just completing the opposite side of the block in the closed fixture in front of the operator. Between the two stations is the turnover device which will invert the block when the right-hand fixture closes and the left-hand fixture opens

COMBINED SET-UPS MAKE THE MOTOR

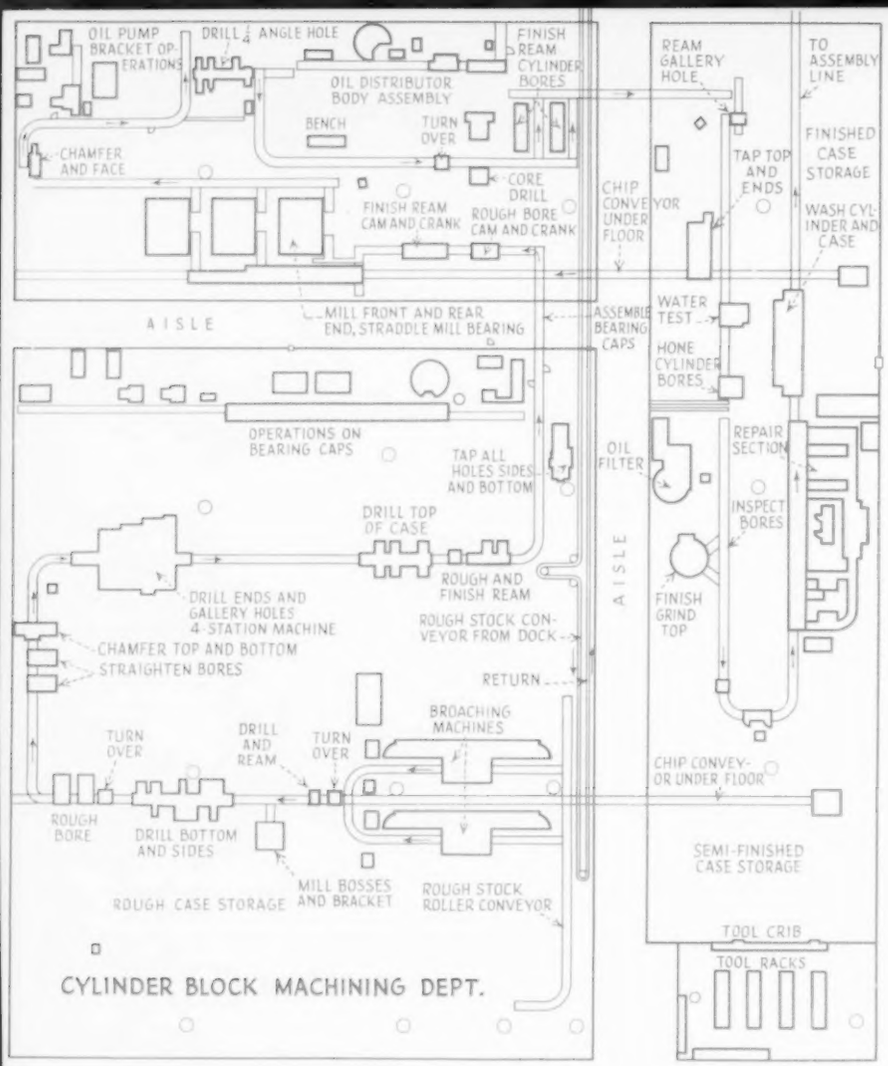
Two plants, Flint and Tonawanda, turn out the Chevrolet engine. In addition the Bay City, Michigan, plant contributes to the manufacture of the engine by supplying certain parts. Oldest and largest of these three plants is that at Flint. It is still the chief source of Chevrolet engines, being capable of supplying some 325 units an hour compared to Tonawanda's 70.

The plant at Flint was started in 1913, five years before Chevrolet became part of General Motors. By the purchase of the old Mason Motor Company, Chevrolet acquired part of a property which today consists of more than 81 acres of land, and buildings having a total floor area in excess of 2,000,000 sq.ft.

Twelve miles of power conveyors at the Flint plant carry 10,000,000 lbs. of material daily. The motor division alone has 59 departments which in normal production employ over 8,000 men who, working together, produce a finished motor every twelve seconds.

Plant No. 4 at Flint is an outgrowth of the old Mason Motor Company plant in which some of the first Chevrolet motors were manufactured and assembled. This plant formed the nucleus of the present Chevrolet organization of 22 plants situated in 17 different cities in the United States and employing over 50,000 men. Because the demand for motors soon outgrew capacity of Plant 4, Plant 5 was started, and later Plant 9 was added to the Motor Division.

Besides the Motor Division, Flint

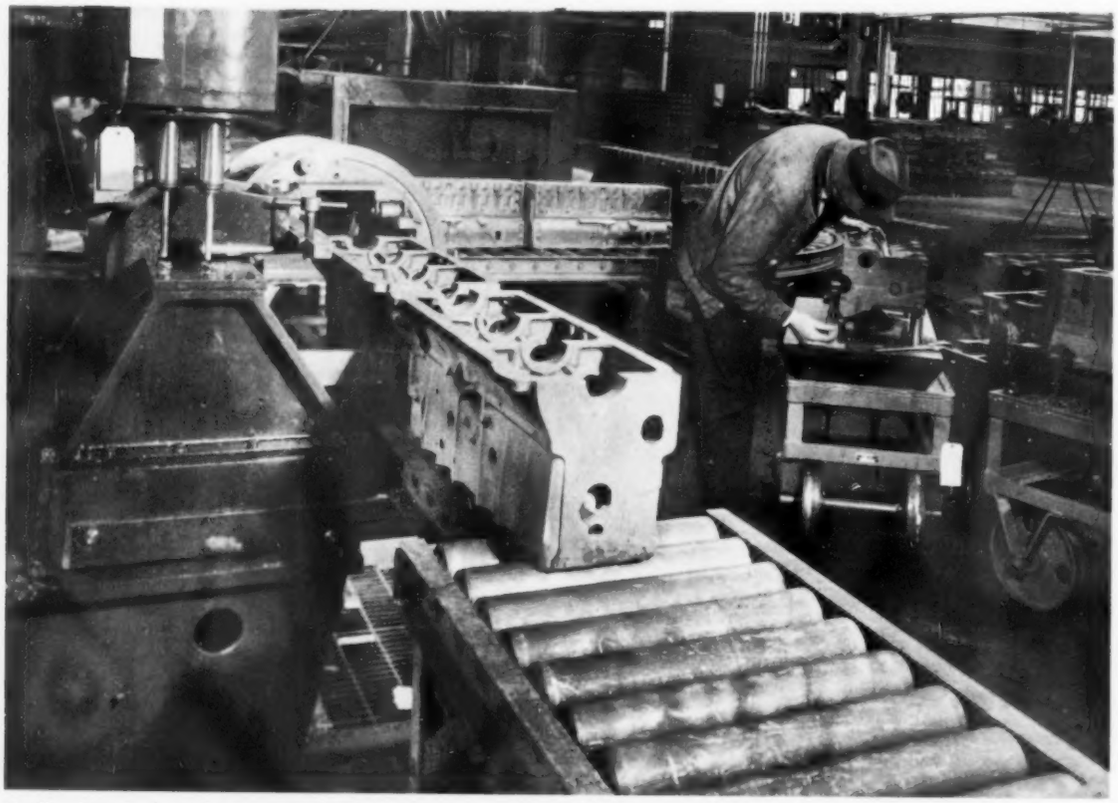


includes an Assembly Division and a Pressed Metal Division. The Assembly Division is housed in Plant 2 built in 1916, and the Pressed Metal Division in Plants 6, 8 and 10 the first unit of which was started in 1924.

Planned From Scratch

The Tonawanda plant was projected in June, 1937, and put into operation early in 1938. The project was planned and executed by experienced personnel with years of service in the older Chevrolet factories. Tonawanda was built from scratch without restrictions of old buildings or old equipment to limit the free play of creative ideas. Plans conceived at Flint and Detroit, but never transformed into brick and steel, saw fulfillment at Tonawanda. These plans are embodied in the plant itself and in the manufacturing equipment housed within it.

Tonawanda has a floor area of 835,000 sq.ft. of which 714,000 sq.ft. are devoted to manufacturing. The manufacturing plant is laid out in two divisions with the motor on one side and the axle on the other. All raw materials are unloaded and all finished goods are loaded inside the



On leaving the broaching machine the blocks are again rolled over in the fixture at the rear, and drilled and reamed for locating holes in the machine at the left. This view gives a good idea of the method of handling

manufacturing building whether by rail or truck. At each front corner of the building is a fully inclosed space for incoming material to avoid the effects of bad weather conditions. The plant has five railroad tracks: one full-length track at each side of the building, one stub track at each side and one short track in the center. Raw materials are carried to starting positions either by conveyor or trailer truck.

Offices at the front end of the building house the laboratory, hospital, plant engineering, standards department, tool design and product engineering. In addition there are the general offices, cafeteria, lockers and shower rooms.

In the manufacturing plant all machines are individually motor driven with some 1700 motors in use. Overhead busbars run the full length of the plant; to these are connected starter boxes, and from the boxes flexible cables run to pushbuttons on the machines. This electrical arrangement eliminates unsightly conduits and makes it convenient to rearrange machines whenever necessary.

Allowance has been made in the floor level for flood conditions. The floor elevation is higher at the back of the building and tapers gradually toward the front which faces the Niagara River.

Insofar as conveyors are applicable to the transportation of parts in process, they are used at the Tonawanda plant. Some five miles of overhead conveyors, two miles of floor gravity conveyors and a quarter mile of power assembly conveyor have been installed. Chips are carried to the end of the plant for disposal by underfloor conveyors covered with grates.

MOTOR MANUFACTURE

THE Chevrolet engine is a six-cylinder, valve-in-head power unit. The bore is 3½ in. and the stroke 3¾ in., giving a displacement of 216.5 cu.in. At 3200 r.p.m. the engine develops 85 hp., its maximum.

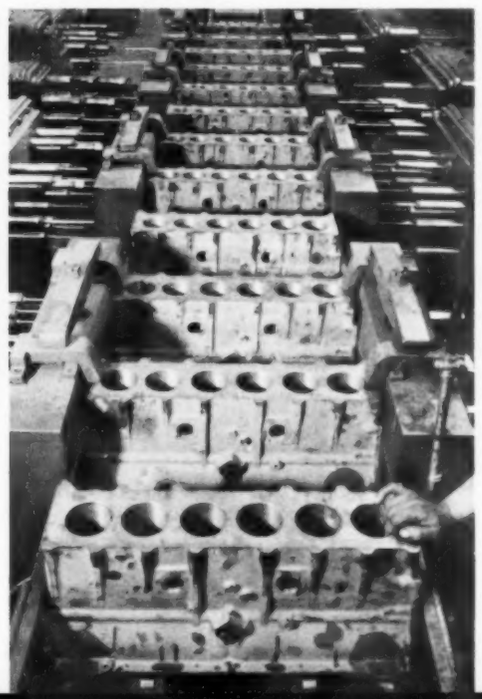
Since Chevrolet motors are made at two separate plants, and additional motor parts at a third plant, repetition will be avoided in describing manufacturing operations by taking some parts in one plant and other parts in another. Obviously it is impossible to cover more than a few of the 1,157 separate parts in a single Chevrolet motor. Only descriptions of operations on the major components will be attempted.

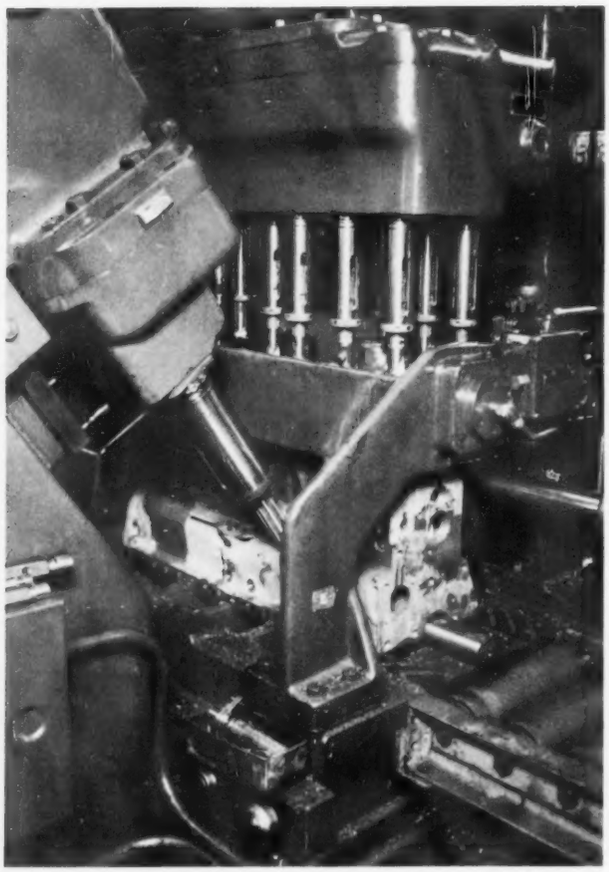
Operations will be outlined on the crankshaft, camshaft, pistons and valves as performed at Flint. At Tonawanda the parts described will be the cylinder block, the cylinder head, the connecting rod and the clutch housing. At Bay City operations described will be those on the carburetor body and the valve pushrod. Pressed metal operations at Flint appear separately.

Rough boring is done in this pair of multi-spindle machines. Noteworthy are the fixtures for locating the work, and the grate covered chip conveyor beneath the roller conveyor

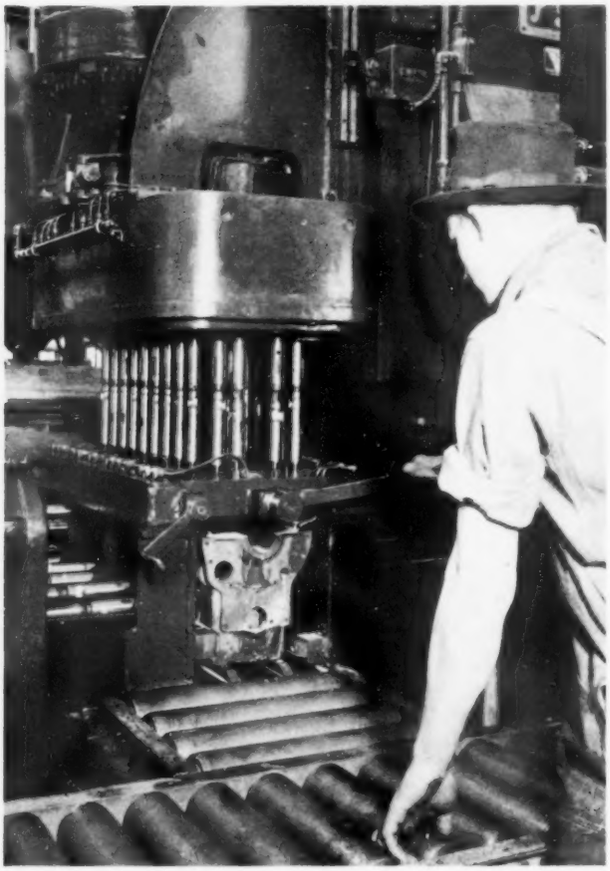
Six large spindles chamfer the tops and bottoms of the bores while the work is held by an equalizing clamp. Additional spindles, operating at an angle at the left, avoid an extra set-up

Two by two the blocks progress automatically through four stations while holes are drilled, reamed and chamfered at both ends. The long oil gallery holes are machined in this set-up





In this last station of a three-station machine, the cylinder head stud holes are chamfered and the distributor hole is reamed. In a similar set-up valve tappet holes are rough and finish reamed



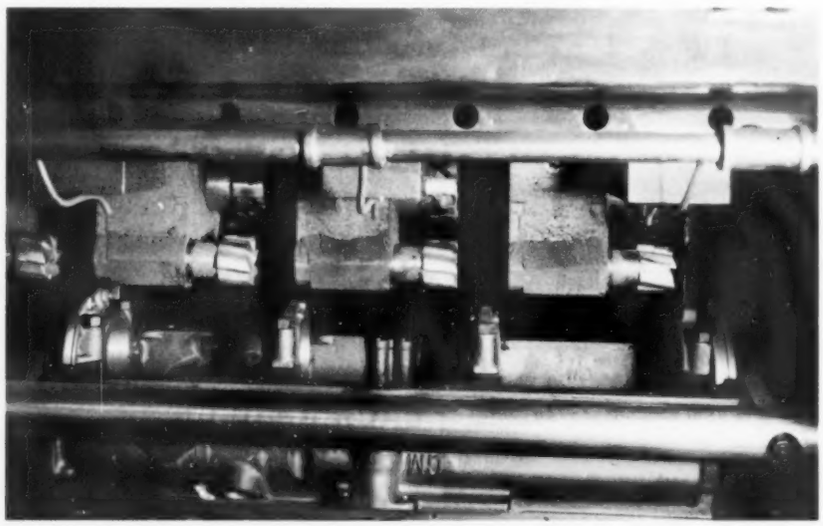
A three-way tapper threads the holes in the bottom and sides of the block. Here 45 spindles are synchronized to cut the correct lead and number of threads in a wide assortment of hole sizes

CYLINDER BLOCK

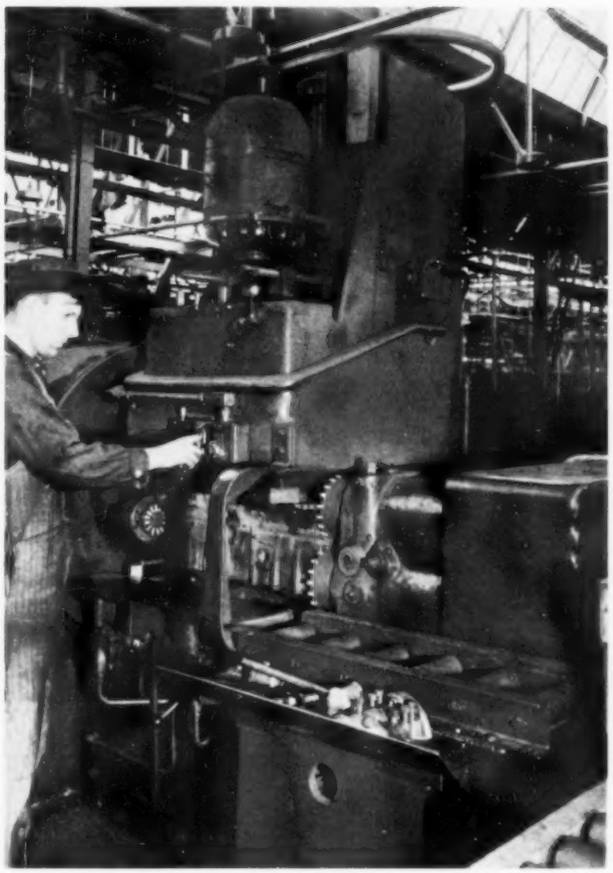
CAST at Chevrolet's Saginaw plant, the cylinder blocks are shipped to Tonawanda by rail and enter the plant on the long siding on the motor side. The blocks are at once transferred to an overhead conveyor which carries them through a washing machine where they are cleaned and dried.

The castings next pass through a paint booth where the inside and tappet cover side are sprayed. Without leaving the overhead conveyor, the cylinder blocks are then carried across the motor side of the plant to the first machining operation.

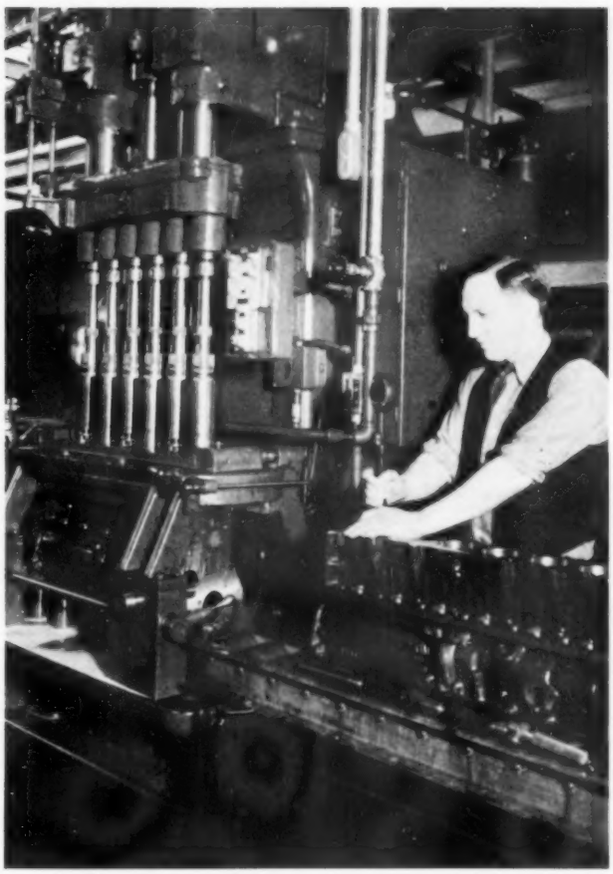
This side of the plant has been laid out so far as possible to keep steel and cast iron separate. Tool cribs are sectionalized and installed at strategic points so the operators do not need to walk long distances for tools. A good deal of thought was given in this in-



The block is lifted while eight boring tools move horizontally to machine the main and camshaft bearings. Similar units finish bore and ream the same surfaces



Milling operations on both ends of the block are evident, but they form only part of the work performed. In addition an intermediate bearing and the pump bracket pad are machined

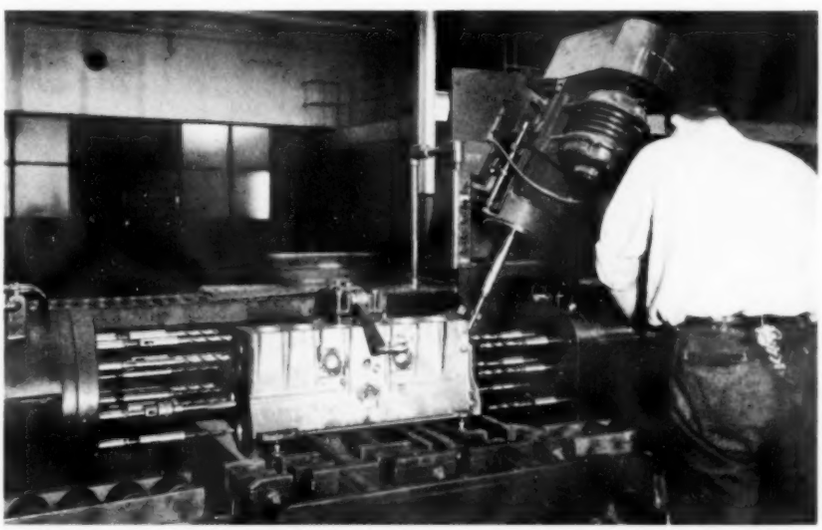


The bores are inspected for size and straightness after being honed in a six-spindle set-up. A direct reading indicator shows the size while a light below the block reflects the finish inside

stallation to the combining of operations in order to carry the parts through their respective processes with a minimum amount of handling. The practice also has the effect of reducing the number of chuckings for each piece which diminishes the chance for error. In this way, it aids in making precise parts and forms a definite contribution to the quality of the Chevrolet motor.

An excellent example of combined operations is the initial step in machining the cylinder block. Four surfaces are broached in a special Cincinnati horizontal machine at the rate of 60 pieces an hour. The block is removed from the overhead conveyor and placed on a gravity roller conveyor which carries it to the first machining position. The machine has two loading fixtures, each of which swings through an arc of 90 deg. to bring the castings into cutting position. Between loading fixtures, an automatic turnover device takes the casting after the work has been completed in the first position, inverts it and brings it to the level of the second loading fixture.

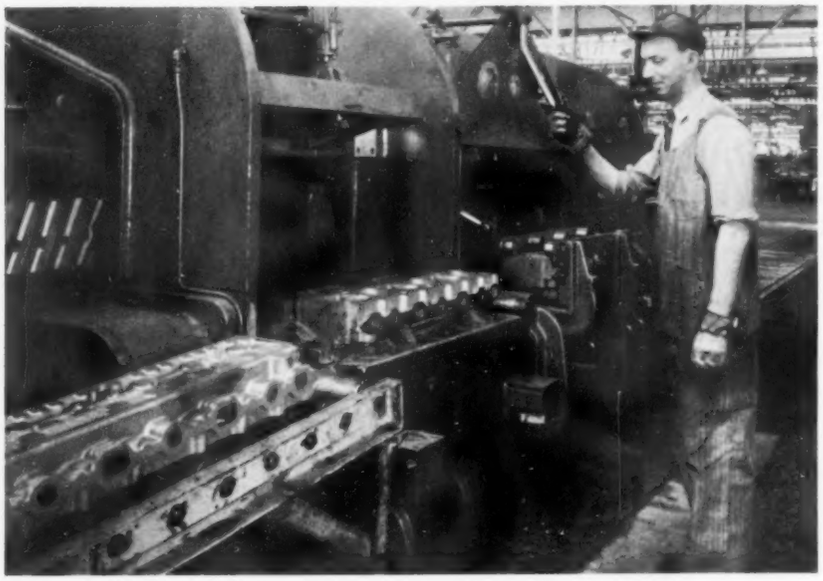
Broaching tools are arranged so that the ram cuts in both directions. The

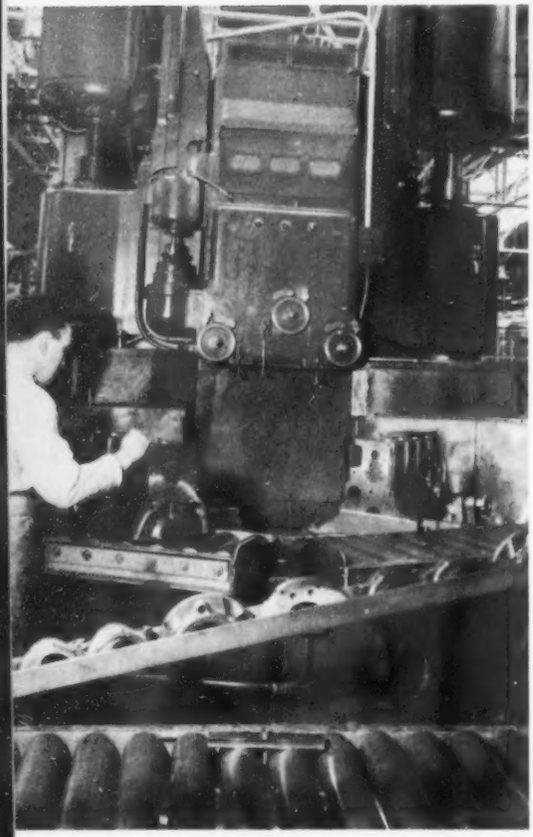


This is called a two-way machine for chamfering holes in the front and rear of the block, but an extra spindle is provided to cut a ¼-in. hole in a third direction. This set-up gives a good view of the fixture pins which locate the block for virtually all of the machining operations

CYLINDER HEAD

On the cylinder head, the first operation is similar to that on the block. Two-station Cincinnati external broaching machines are used with a turnover device between the loading stations. At each station two faces are machined: (1) the top and rocker side, (2) the bottom and manifold side. About the only operating difference between these machines and those used on the block is that the heads are pushed into position by hand instead of hydraulic transfer rods





Tops of the blocks are ground in this merry-go-'round arrangement. This is the final machining operation; from here the blocks travel through a washer to the motor assembly line

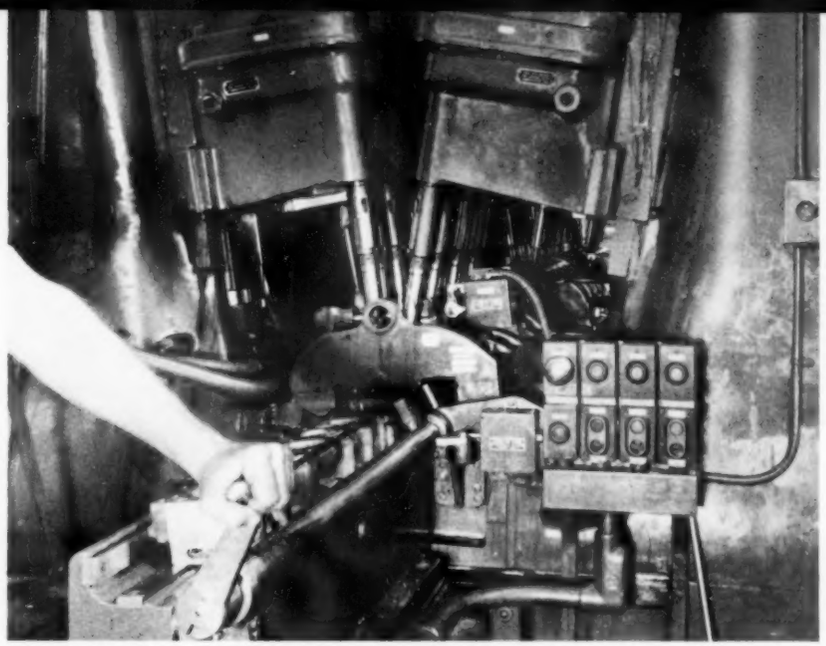
Top and push rod side of the cylinder head are drilled, reamed and tapped in a Natco six-station machine equipped with four vertical and four horizontal heads. Sixty-nine spindles are used. The heads are held in six fixtures mounted on an automatic indexing table. This operation follows a similar set-up on the bottom and manifold side

two loading fixtures come into the cutting position alternately with one always under cut while the second is being unloaded and reloaded. In the first position, a single flat cut is taken across the bottom or pan side of the cylinder block. In the second position, cuts are taken on the top, on the valve chamber cover pad and on the oil filler boss.

Blocks are loaded and unloaded by means of two hydraulically actuated transfer rods. The first of these removes the completed block from the right-hand loading fixture and shoves it to the turnover device and at the same time brings a second block into place. The second transfer rod removes the work completed at the left hand station and pulls a new block into place from the turnover device. The entire machine is so synchronized that it cuts practically all of the time. Older methods of performing the same work required entire batteries of machines to take these cuts. The two cylinder block broaching machines in use at Tonawanda are arranged to feed into a common roller conveyor.

Holes Placed for Locating

The next operation consists of drilling and reaming two locating holes in the underside of the casting. The set-up is a simple one, with a pair of spindles for drilling and another pair for reaming, the block being machined in two positions. The importance of the operation at this point is that these holes are used wherever possible throughout the cylinder block machining line for positioning the casting. A special Sundstrand tunnel-type mill is



When the handle is swung to the left, fingers on the transfer rod engage the head castings and carry them successively through the three work stations of a Footburt machine. Work done here is to core drill, ream and face twelve valve seats

next employed to machine the side bosses that could not be reached in the broaching operation. The machine has three spindles which mill respectively the oil filler boss, the gas pump boss and the generator bracket boss.

Another fine example of the way operations have been combined is in the next set-up which consists of a Footburt four-station drilling machine. In these four stations, 127 holes are drilled in the block with nine heads. This machine is also of the tunnel type with the castings coming in on a roller conveyor at one end and passing through the four stages. In each station the block is lifted slightly and held securely in position from the locating holes. A hydraulic mechanism pushes the four blocks simultaneously into each successive station.

The next two operations consist in rough boring and semi-finish boring the cylinder blocks. In each case, six-spindle machines are used. The work is pushed from the conveyor into the loading fixture. One lever raises the locating plugs, which fix the position of the work, while another clamps the block securely in place.

After the semi-finished boring, which is a duplicate of the rough boring process, the cylinder bores are chamfered top and bottom, and three holes are drilled at a 20-deg. angle. The castings are pushed into place against a stop at which point the rollers drop the block onto the locating plugs. An equalizing holddown clamps the work in place. Each of the six spindles on this machine has an expanding cutter in the bottom, which chamfers the lower end of the bore, and a fixed tool at the top, which simultaneously chamfers the upper end.

Eight Natco units arranged to form four two-way stations are used in the next set-up which drills, chamfers, counterbores, reams and taps the ends of the cylinder block using 47 spindles. The operator pushes the work to the first loading station from which it is carried automatically to the succeeding stations two blocks at a time. Part of the work done in this set-up is the drilling of the oil gallery holes which run the entire length of the block. In order to synchronize this comparatively long job with other shorter operations, each of the four stations does a part of the oil gallery hole. The entire set-up is controlled by one operator by means of a single push-button station.

Two other multiple drilling and reaming set-ups follow this. The first consists of a three-station Footburt machine which drills the cylinder stud holes and the distributor holes, and chamfers them. The block is then turned over and passes through a two-station machine where the valve-tappet holes are roughed and finished reamed. In the next operation, all holes in the bottom and sides are tapped in Fox three-way machine having 45 spindles.

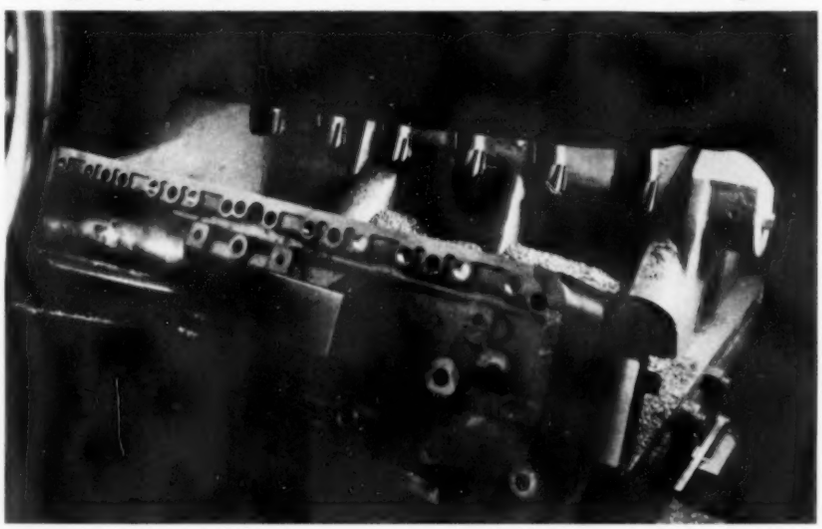
The caps are machined on a separate line which is arranged to feed into the block line at this point. Here the caps are assembled to the bearings.

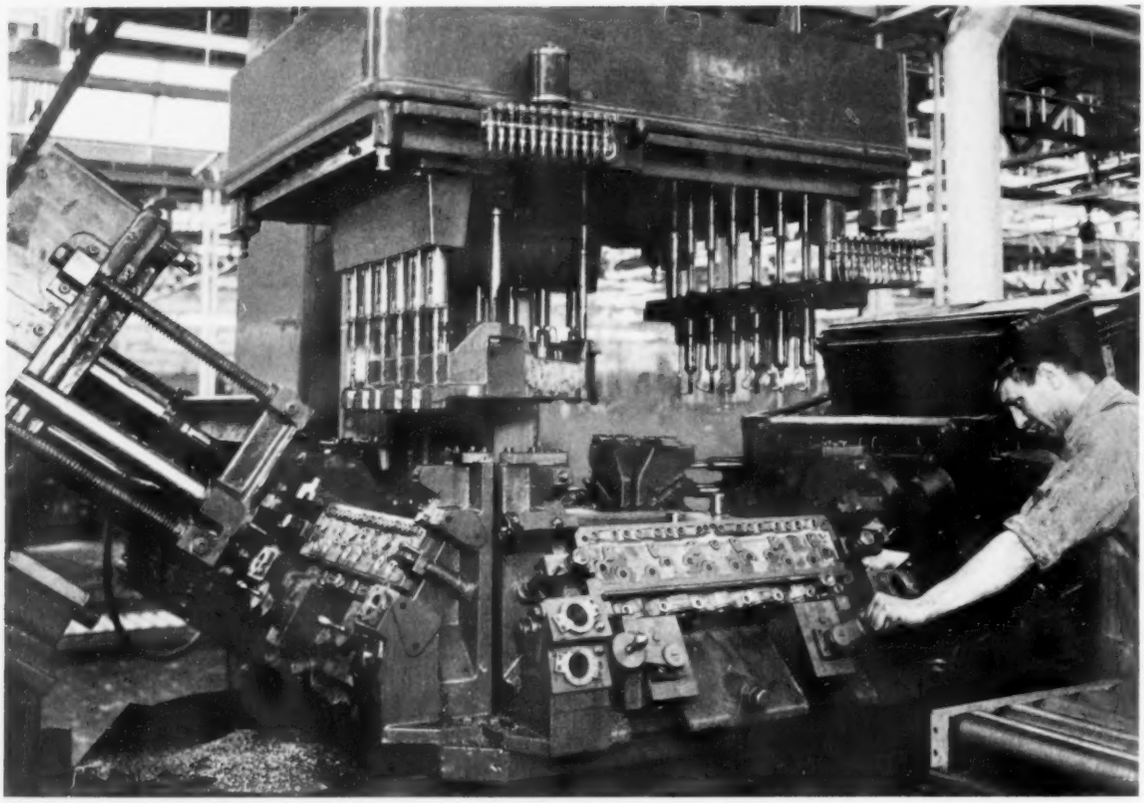
Boring the Bearings

In the next set-up, the cam and crankshaft holes are rough and finish bored and reamed. This work is done in three stations in an Ingersoll special machine. At each station all the holes are operated upon simultaneously using eight cutters. The machines are of the tunnel type with the blocks being carried along by transfer rods from one station to the next. At each station the block is lifted up into position under the cutters. The cutters then move horizontally to complete the work and recede automatically, allowing the block to be dropped back to the conveyor level. The block then goes to one of a battery of three Ingersoll milling machines which also exemplify the combining of cuts in a single unit. Each machine has three heads, a vertical head, a horizontal head and a rotary head. Each head has three cutter spindles, and between them they take ten separate milling cuts on the block. The operator has only to load and unload the machine and start it by means of a push-button switch. The block is located from the finished pan rail and the two reamed locating holes.

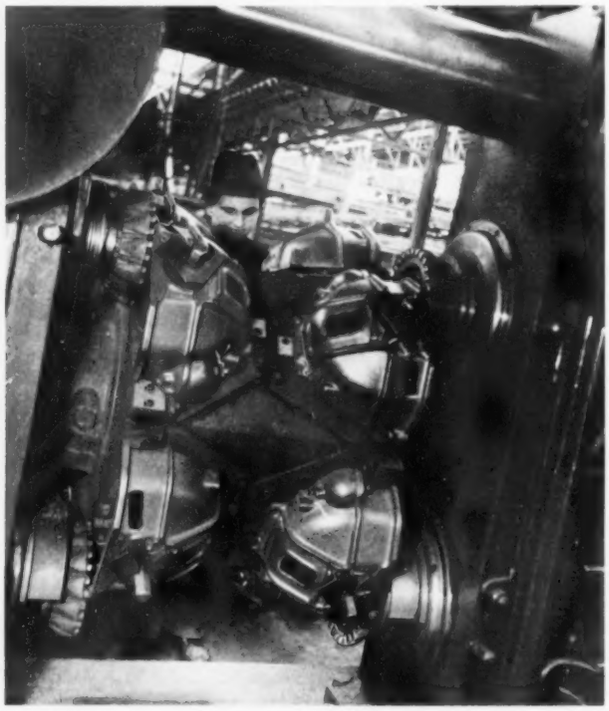
When the machine is started, the

A six-spindle Sundstrand machine mills spots for gaskets at the sparkplug holes. A duplex fixture permits loading one side while the other is unloaded. The head is set at a slight angle so the vertical cutters will mill the spots in the correct position





Spark plug holes are drilled, counterbored and tapped, valve guide holes are spot faced and two end holes are drilled and tapped in this Natco four-station machine. The work is loaded at the front of the machine and carried through the three hydraulically-operated working positions on a rotating table. The vertical spindle box contains eighteen spindles and the horizontal units sixteen



CLUTCH HOUSING

Clutch housings are first milled on the bottom face in a Davis drum-type machine. Each of five work positions carries fixtures for two castings. The work is located from three outside points

rotary unit travels against a positive stop which brings it into cutting position. A drum feeds to depth the center cutting spindle which machines the oil slinger groove and the rear bearings. The rotary head then turns through a complete revolution carrying the two outer spindles which rough and finish mill the rear of the block.

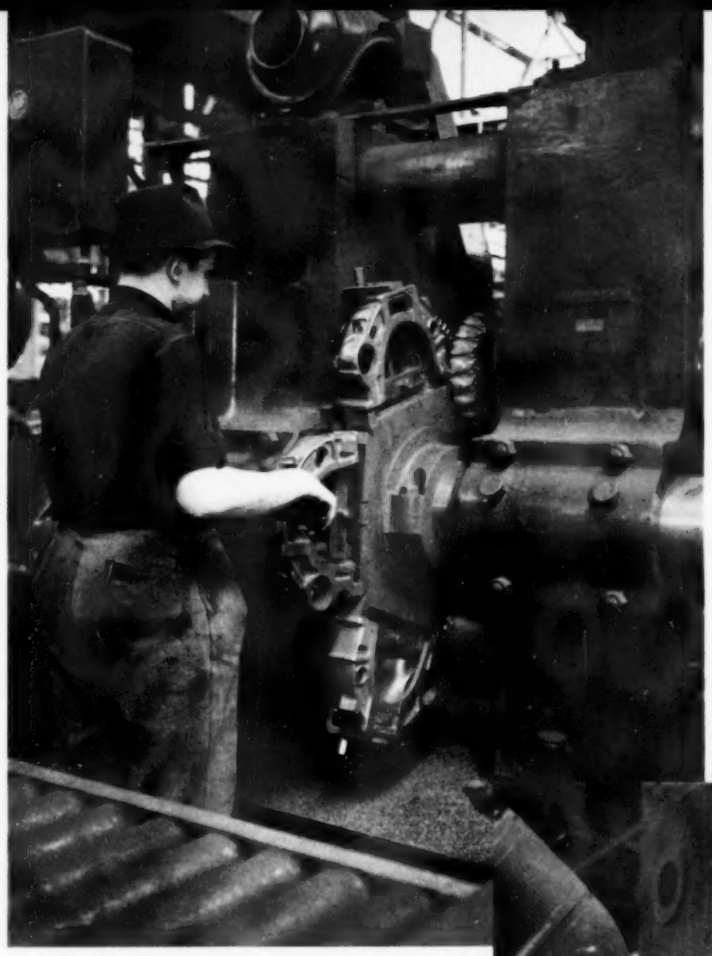
Horizontal Head Finishes Front

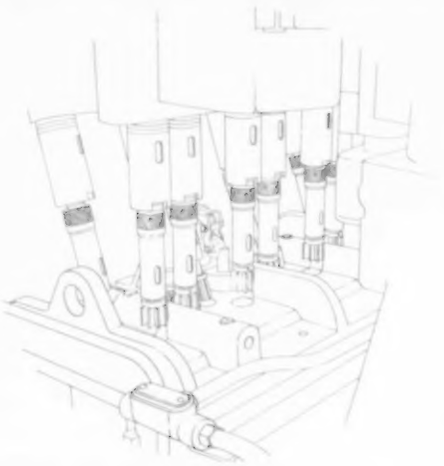
While this work is going on, the horizontal milling head, which carries two spindles for roughing and one for finishing, completes the work on the front end of the block. This head is provided with rapid approach, a feeding interval and a quick return.

At the same time, the vertical head travels downward with two spindles straddle milling the front and back of the rear intermediate bearing and a third spindle machining the oil pump bracket pads. When these operations are completed, all spindles are automatically withdrawn and returned to the starting position.

A Fox special machine then chamfers and faces both sides of the rear intermediate bearing, which provides the thrust surfaces for the crankshaft, and drills a $\frac{1}{2}$-in. hole at the front end at a 60-deg. angle.

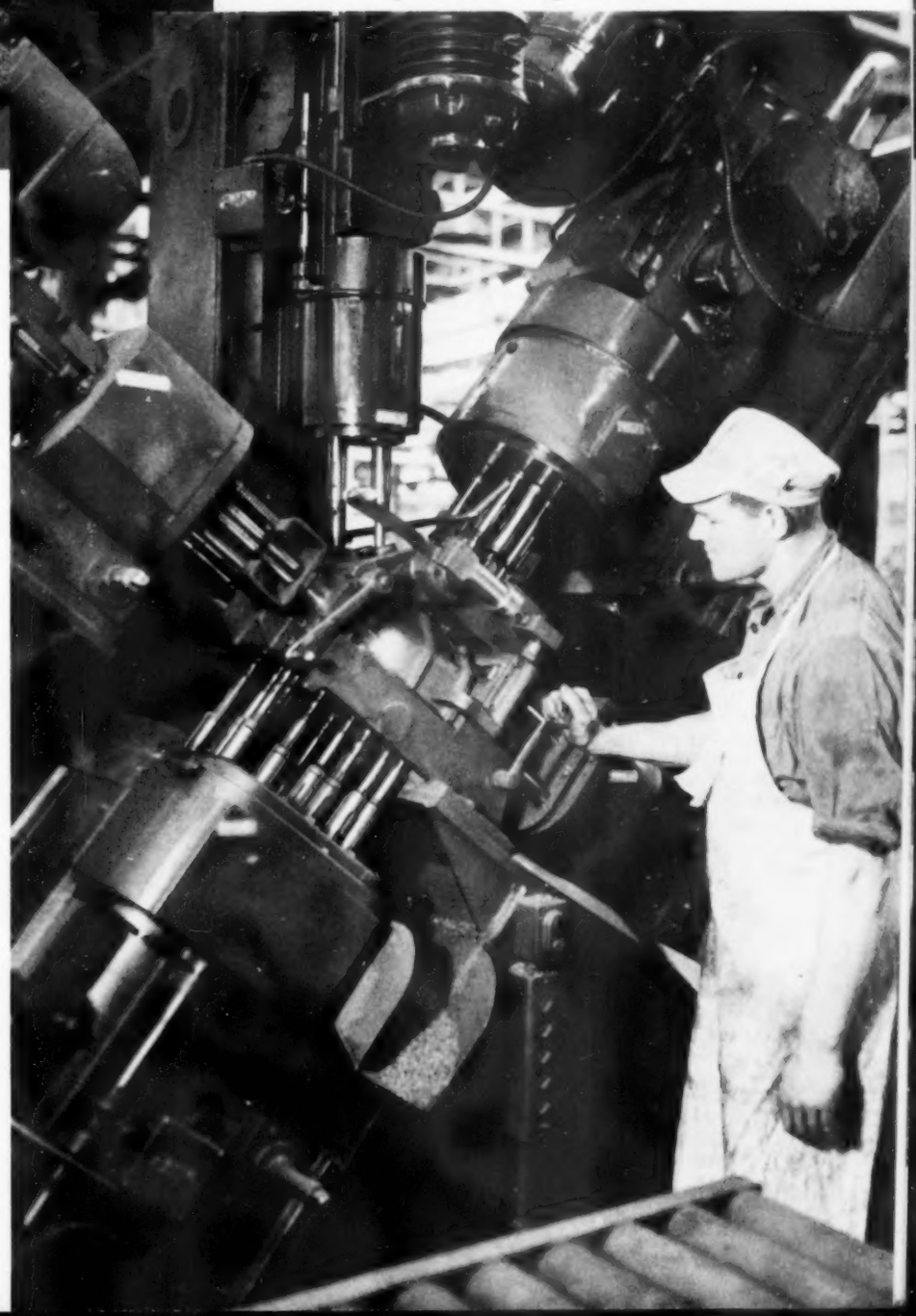
At this point in the line, the pump brackets join the cylinder block after having been drilled in a three-station





Motor and transmission faces are milled in a second drum set-up. Only one casting is chucked at each station because the cutters work from both sides at once. As in the previous set-up, both rough and finish cuts are taken

All holes in the clutch housing are drilled in a six-way Fox machine. In addition the transmission pilot hole is rough bored and the starter pilot hole is rough and finish bored

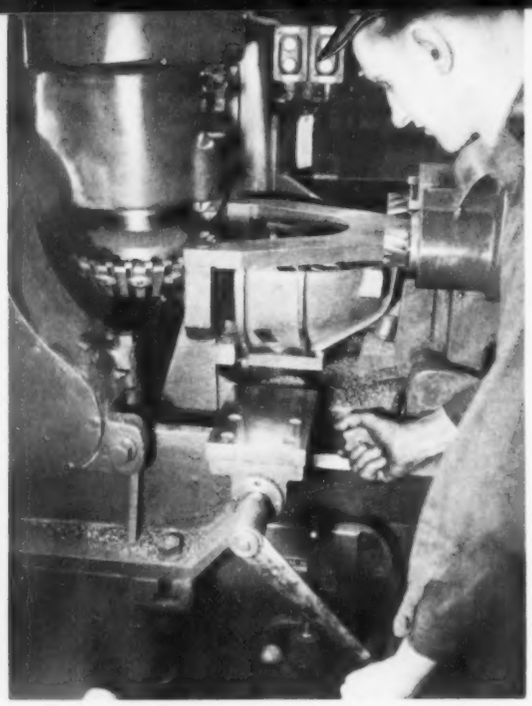


Bradford vertical machine. The brackets are assembled to the cylinder block, and the bearing caps are removed. This is to allow the drilling of a series of oil holes at various angles. The work is done in a Fox five-station machine which handles the work in much the same way as the multiple drilling operations previously described. The caps are then reassembled, and the block is turned over to core drill, ream and chamfer the distributor holes in a two-station Fox machine with two spindles at each station.

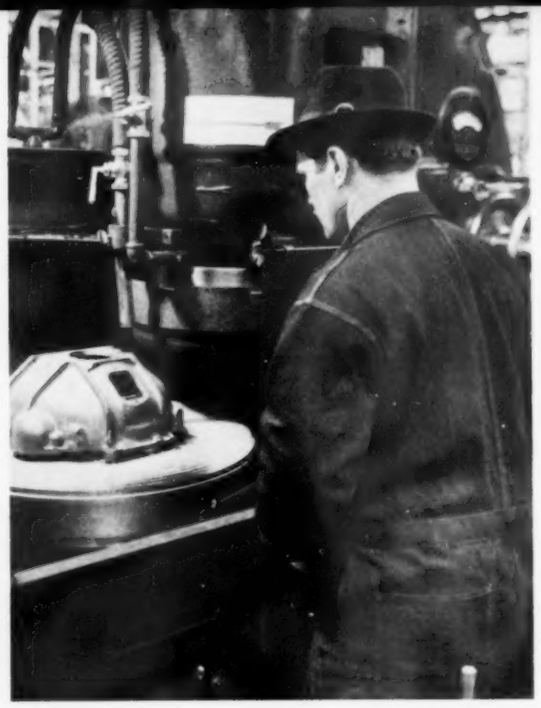
The cylinder bores are finish reamed one at a time. This operation is done by a pair of Footburt four-spindle machines, one on each side of the conveyor. Each machine uses only one spindle on each block, assuring uniformity of size for the six bores.

The block is again inverted to ream the oil gallery hole in the front end and to chamfer all the holes in the front and rear of the block. At the same time, a 30-deg. hole is drilled using a separate head. The machine for performing this work uses eighteen spindles. After the tops and ends are tapped in a four-way Footburt machine, the block is plugged for the water test and then tested.

A Barnes six-spindle honing machine completes the final operation on the cylinder bores. As the blocks leave this machine, a light under the con-



At the left the cutter passes over the inside face of the housing to machine six small circular bosses. The two end mills at the right machine the top bosses. A special Milwaukee mill drives the cutters

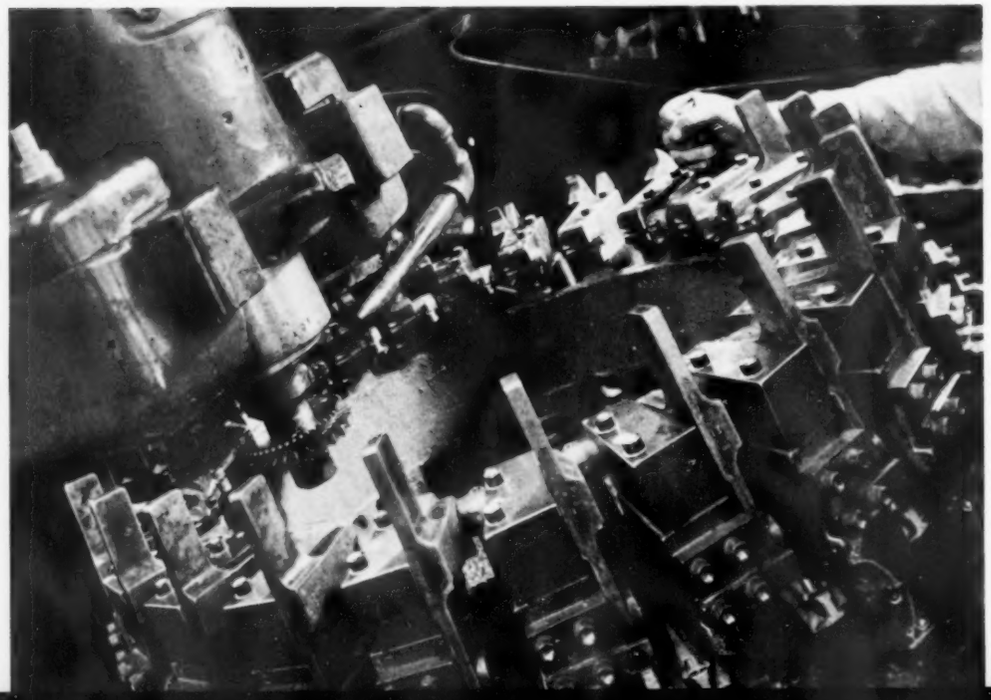


The clutch housing is held on a magnetic chuck in a Blanchard vertical grinder while the transmission face is finished. Covers completely inclose the work table during operation so the copious flow of coolant can be kept inside the machine

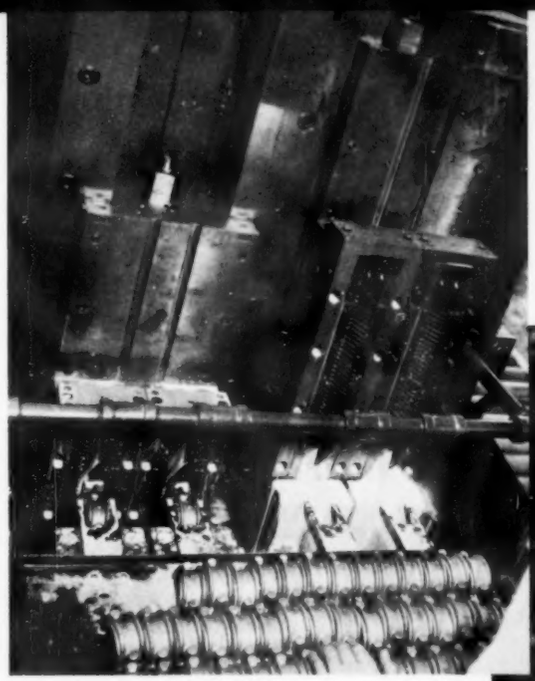
veyor aids the inspector in checking the finish. He also uses a Federal direct-reading gage to inspect the bores for size and taper. The blocks then go through a Hanchett grinding machine with a rotary table. They are loaded and unloaded at the front of the machine and are carried around it through an inclosed tunnel which houses the grinding wheels mounted on vertical spindles. In this set-up the top of the block is finished smoothly, making it tight against leakage when assembled with the cylinder head.

The blocks are then returned to the conveyor where they pass through a conveyor-type washing machine. They are blown out to remove all moisture and follow along the conveyor which leads directly into the main motor assembly line. The departments machining other motor parts are located further down the line where they will feed parts into it at the locations required for their assembly to the blocks.

Each of this flock of spindles has a special mission. Most of them chamfer holes in the motor face of the clutch housing, but two spotface inside holes. The machine is a one-way Fox horizontal



The pinch-bolt slot is milled, and the pinch-bolt boss is faced in a tilted table Ohio milling machine. The table rotates continuously with two cutters in use on a single spindle. Connecting rods are located from the wristpin holes and are clamped by pivoted wedges

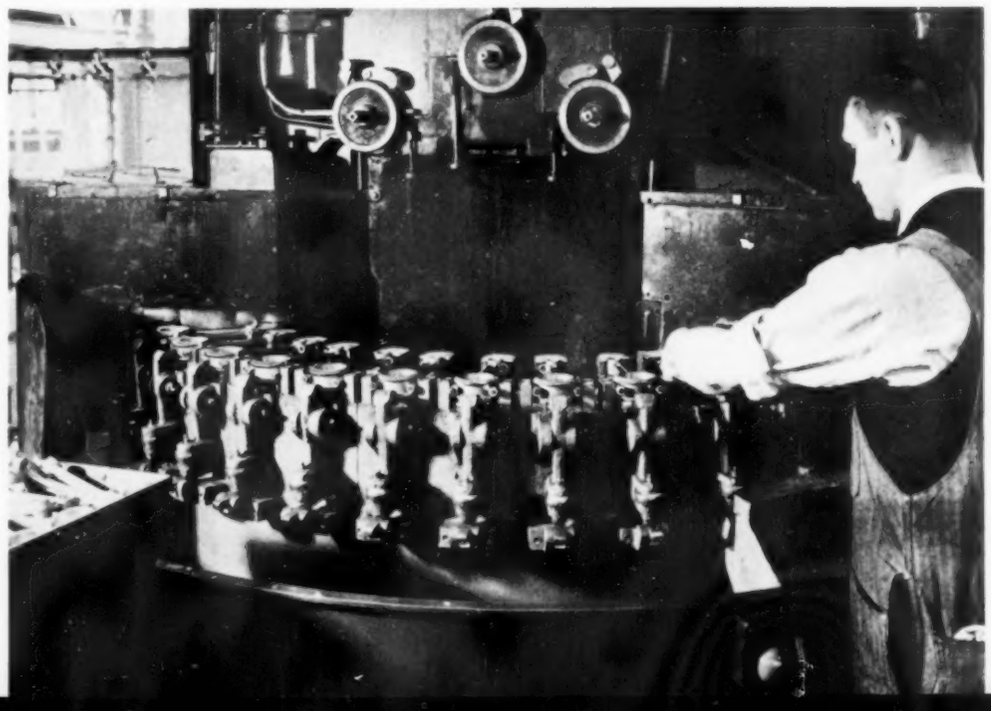


Connecting-rod caps are broached on the sides in a double-ram Oilgear machine. Two caps are chucked in front of one ram which descends, takes the cut, while the other ram rises. On the upstroke finished caps are removed, a new pair loaded for the next stroke

CONNECTING RODS

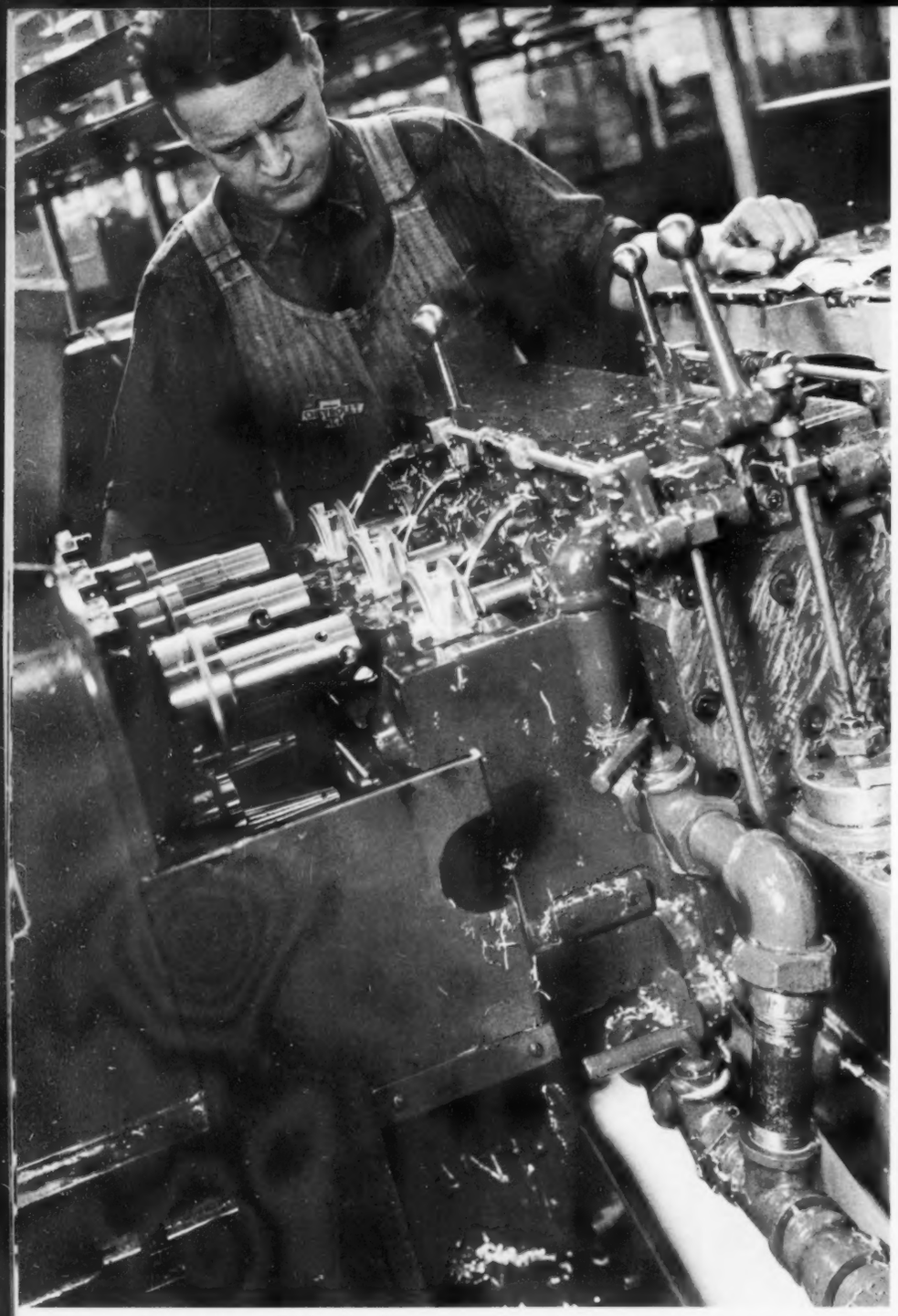
CHEVROLET connecting rods are made from steel drop forgings. The forgings are made at Detroit and shipped to Flint and Tonawanda. The operations at Tonawanda described here begin by Rotoblasting the rods and caps. The sides and bosses of the rods are then coined in a Bliss press, and the rods are straightened. Next the wristpin holes are drilled, reamed and chamfered making the rod ready for the broaching operation illustrated.

Pickling, tinning and babbitting processes are built right into the manufacturing line. Whereas the work is handled in tote boxes on roller conveyor for machining, these operations are served by overhead conveyor. The pickling room is glass inclosed.



Broaching is also used for the joint faces of caps and connecting rods. In this chain-type Footburt, fixtures are provided for eight caps alternating with eight rods. The broaching section is fully inclosed to permit the use of a liberal supply of coolant

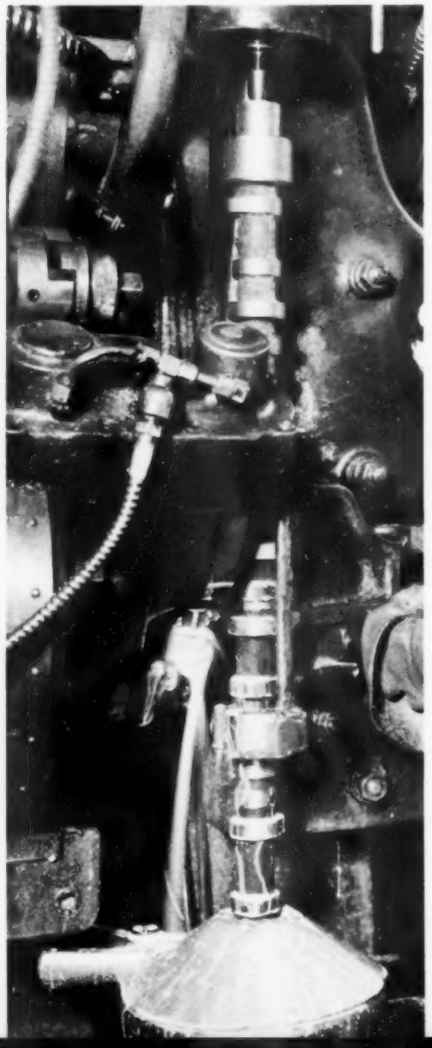
After assembly, connecting rods and caps are ground on both sides in a rotary Hanchett grinder. Cam-operated clamps are arranged to grip the rods as they pass into the working inclosure and release them when they emerge. Operation is continuous



Final finish is given the connecting-rod crankpin and wristpin holes by a Heald diamond boring machine. Two heads each carry six spindles to fine bore the holes in three rods. Fixtures are of the duplex type which permit loading three rods while the other three are working. Diamond boring both ends at once is an innovation

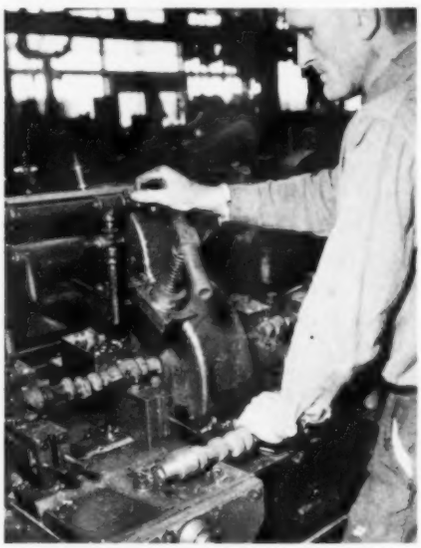
Both ends of the camshaft are centered simultaneously in a Fox machine. The forging is held in hydraulically actuated V-blocks which exert enough pressure to keep it straight. Endwise location is from the center distributor gear blank

Gear teeth for the distributor drive are cut in a four-spindle rotary Lees-Bradner machine. Camshafts are chucked vertically, and

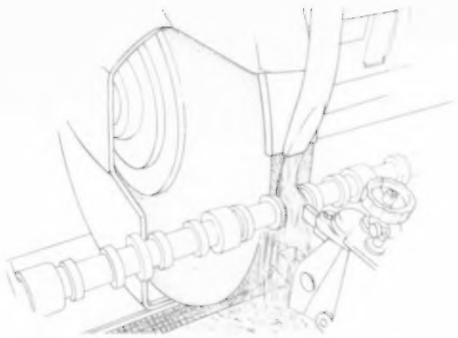


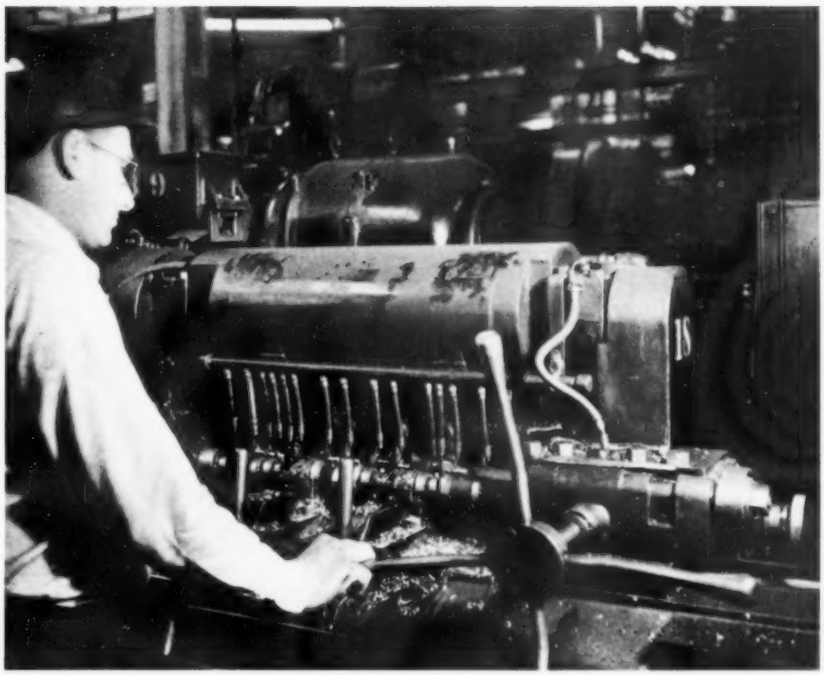
CAMSHAFT

THE CAMSHAFT forging is delivered to Flint from Chevrolet's Detroit plant. It is made of steel, corresponding closely to SAE 1040, already normalized when it reaches Flint. The shaft finishes to 28½ in. in length and has four main bearings. Since each shaft has twelve cams and an eccentric, and since all of these irregular surfaces must be held accurately to size and angular position, the methods employed are particularly ingenious. The camshaft department is completely conveyorized with the work carried overhead on series of continuous monorails.

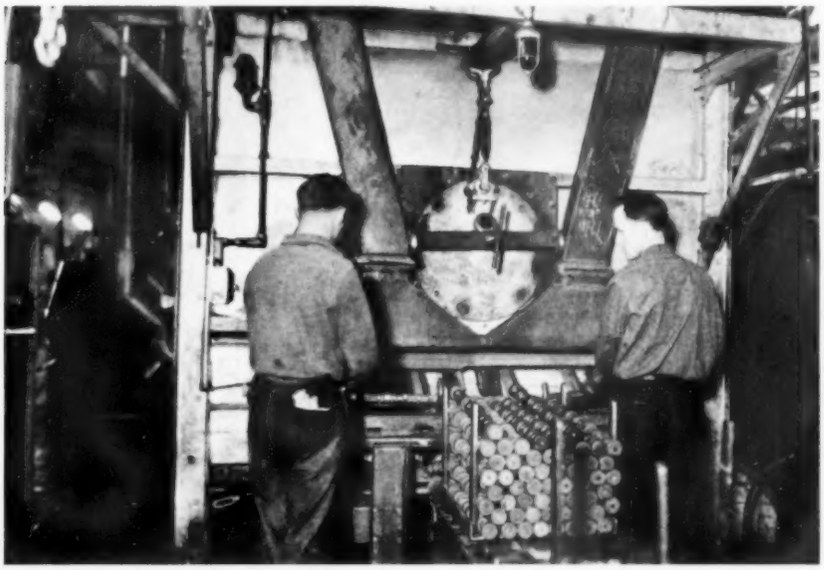


The timing gear fit and all bearings are turned, and the sides are chamfered in a Sundstrand center-drive stub lathe. Tools in front do the turning while those in back swing forward to do the chamfering. A keyway operation follows one is completed as each station reaches the front of the machine. The helical teeth are cut by hobs tilted at the proper angle

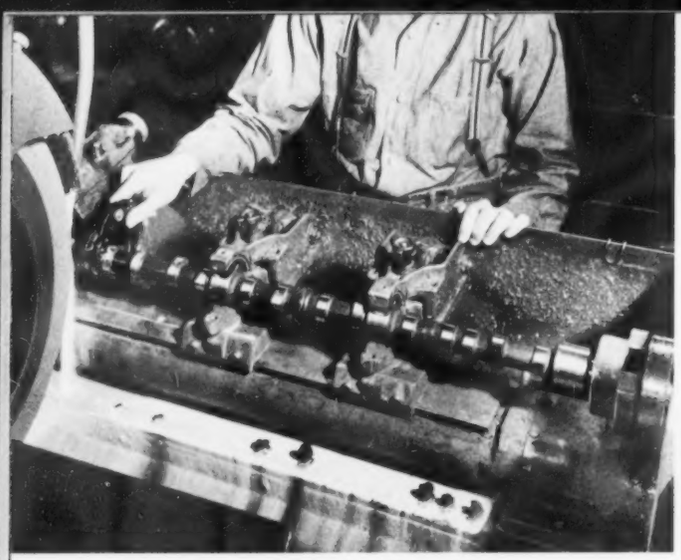




A Melling cam lathe turns the cams, gas pump eccentric and straightening diameters. The work is driven from the end and is supported by roller rests from the two intermediate bearings previously rough ground. Tools advance and recede to form the cam contour; the machine stops automatically when the cycle is complete



The controlled atmosphere in the Holcroft gas-fired furnace keeps scale to a minimum. Camshafts are fed through by a pusher mechanism. Upon ejection at the other end (illustrated) they are placed in fixtures that spin them vertically while being quenched by water spray to keep them straight and to insure uniform hardness

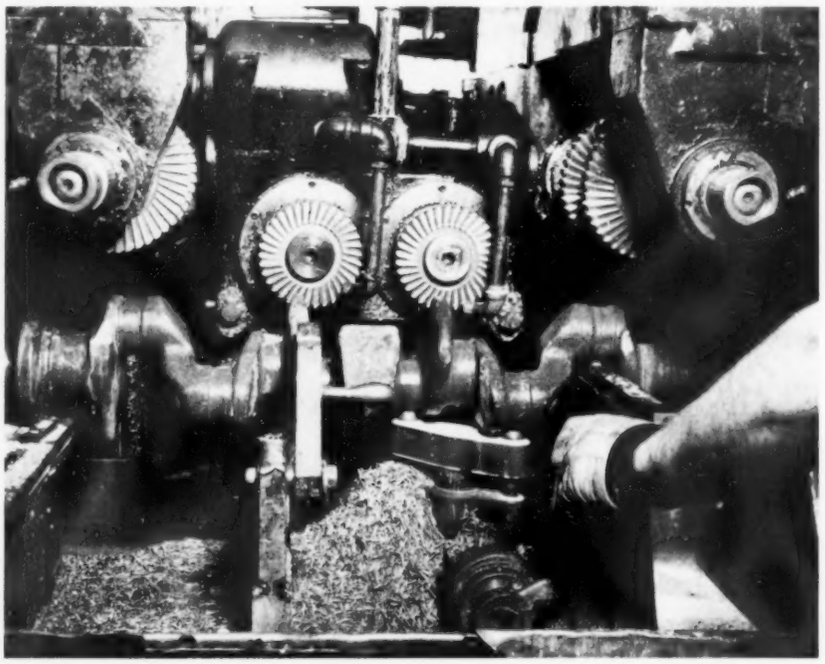


Landis cam grinders rough and finish the cam surfaces. The wheel indexes for each cam in turn, starts slowly, speeds up for the grinding process and sparks out at reduced feed. It is trued after each shaft with automatic adjustment for the new wheel size. Main bearings are polished in a Shraner machine. Abrasive is supplied on paper tape which is fed automatically as each new camshaft is chucked. Cam operated levers are used to apply pressure at each bearing surface

CRANKSHAFT

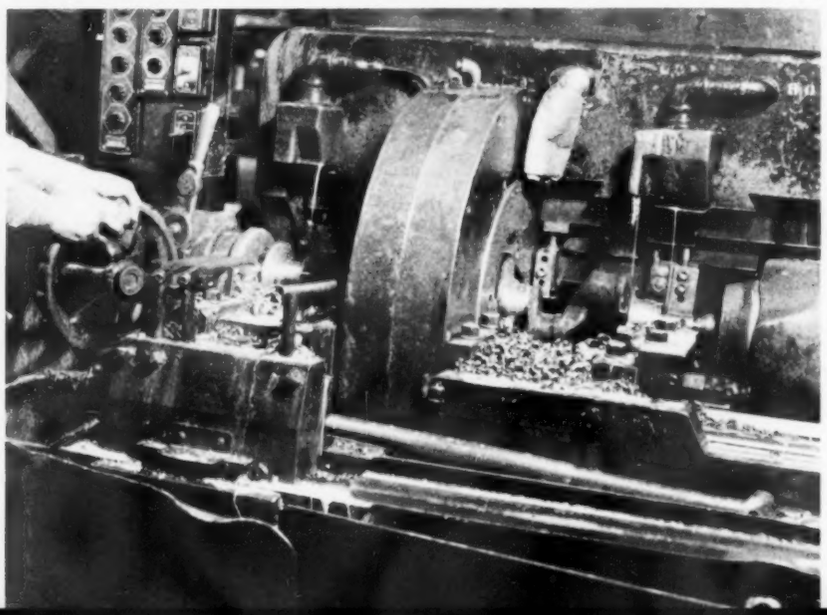
LIKE the camshaft, the crankshaft forging is made at Detroit. It is made of SAE 1045 straight carbon steel with the carbon range held somewhat more closely than the SAE specification.

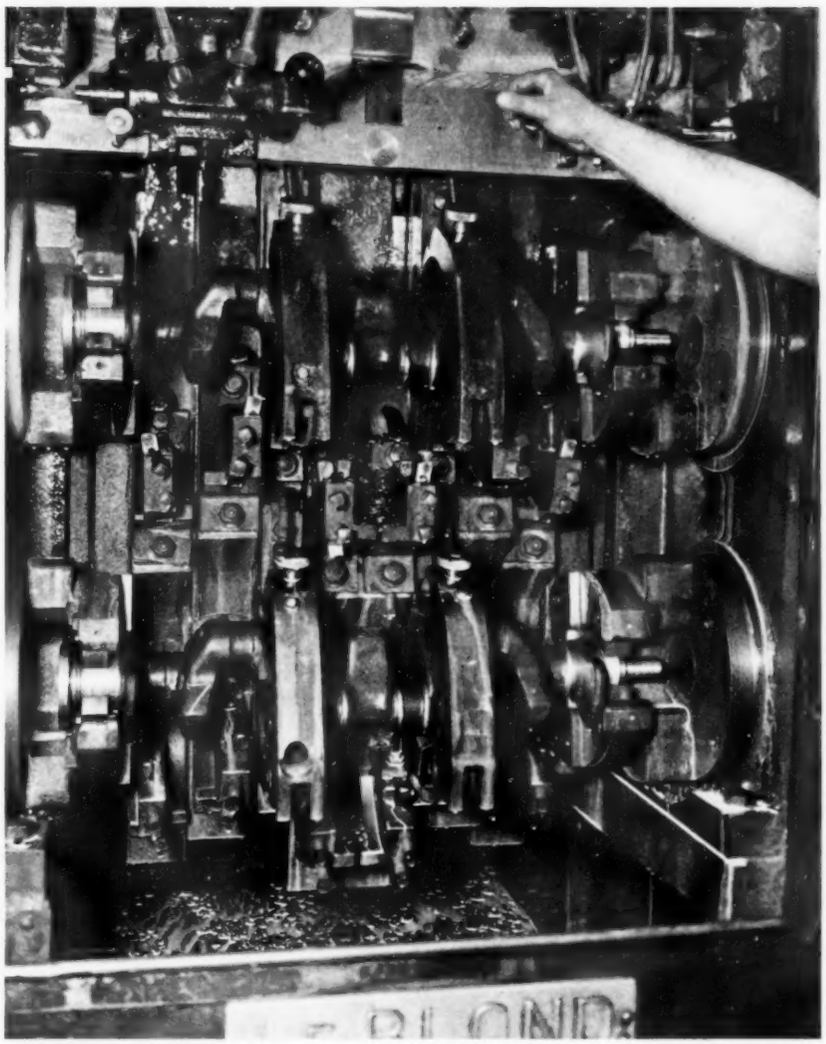
Since the crankshaft is a comparatively heavy piece the department is fully conveyorized, and many auxiliary lifting devices are provided for transferring the work from the conveyor to the machines.



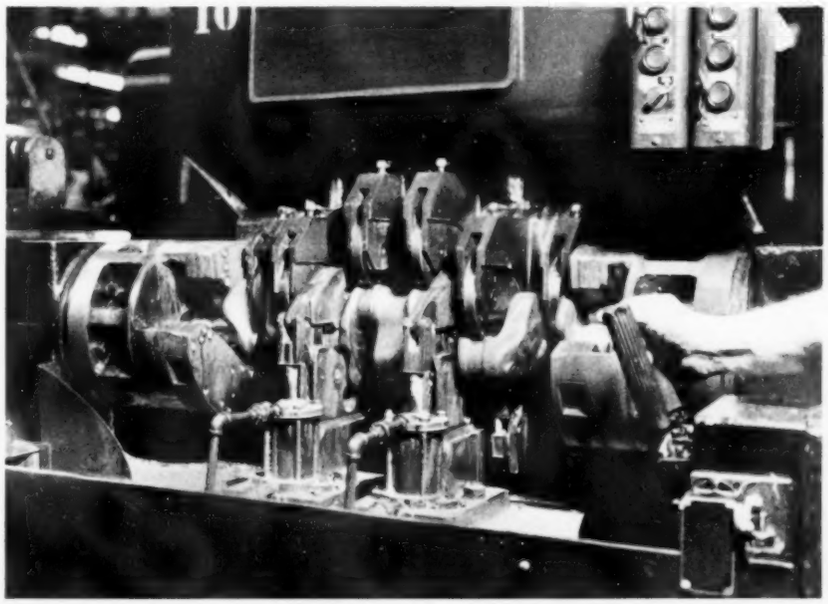
After the crankshafts have been straightened and centered, eight locating spots are milled simultaneously in a Producto-matic machine using two pairs of straddle mills and four end milling cutters. These spots are used to chuck the work in the next operation

Wickes special lathes are used to rough turn all main bearing diameters and the front end flange. These are center-drive machines which chuck the work from the crank arm. A similar set-up finish turns the main bearings and the outside diameter of the flange

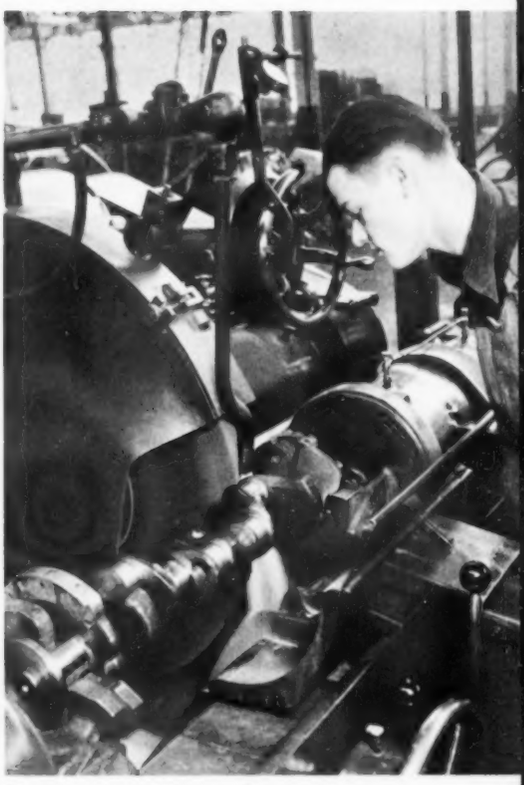




Crank arms and counterweights are faced in a Le Blond lathe, two shafts at a time. This machine increases the work r.p.m. automatically as the tools advance thus maintaining a constant linear cutting speed

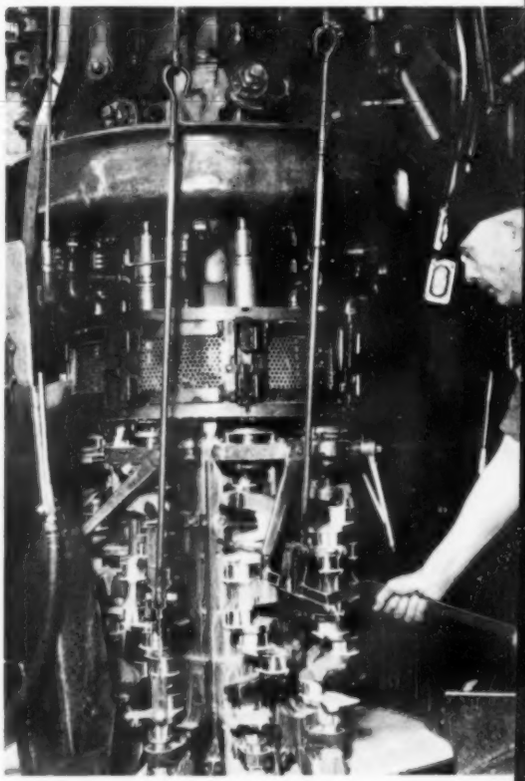


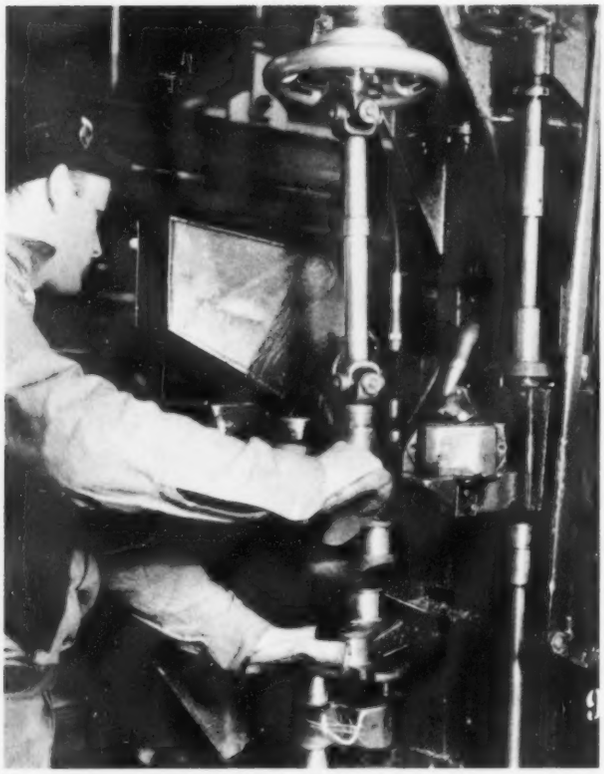
A lathe made by the Crankshaft Machine Company rough and finish turns the crankpin bearings. Each tool follows its pin around the throw of the crank arm to complete all pins at one setting



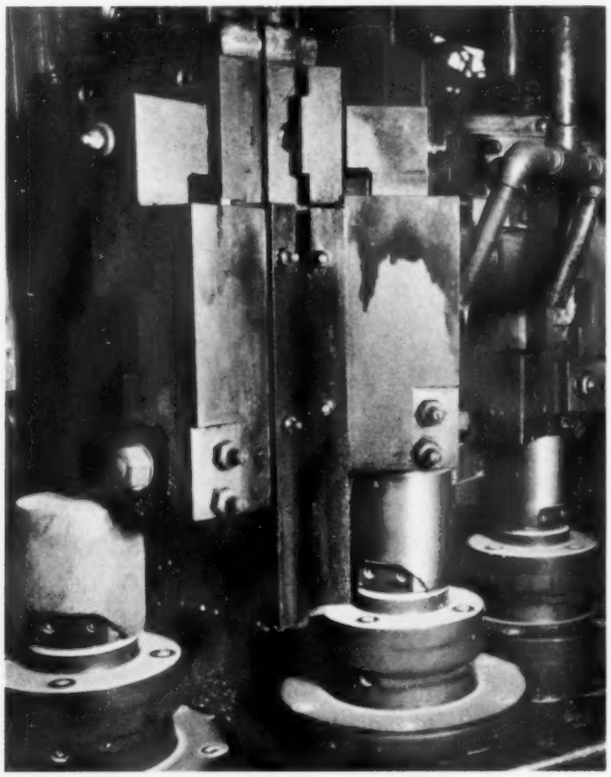
Pins are ground in a Landis machine, one at a time. The crankshaft is chucked in offset fixtures which can be rotated to align each pin in turn with the centers

The pilot bearing hole in the flange end is drilled and counterbored in a Davis Rotomatic eight-spindle machine. The work is chucked vertically and is carried around the machine while being cut





Crankshafts are dynamically balanced in a machine designed by General Motors especially for this purpose. As the shaft is rotated at operating speed, any out of balance is indicated by the path of a series of light spots reflected on a ground glass in front of the operator. If the light keeps between two red lines the shaft is within ½ in.-ounce, the allowable limit. Shafts out of balance are corrected by grinding or drilling



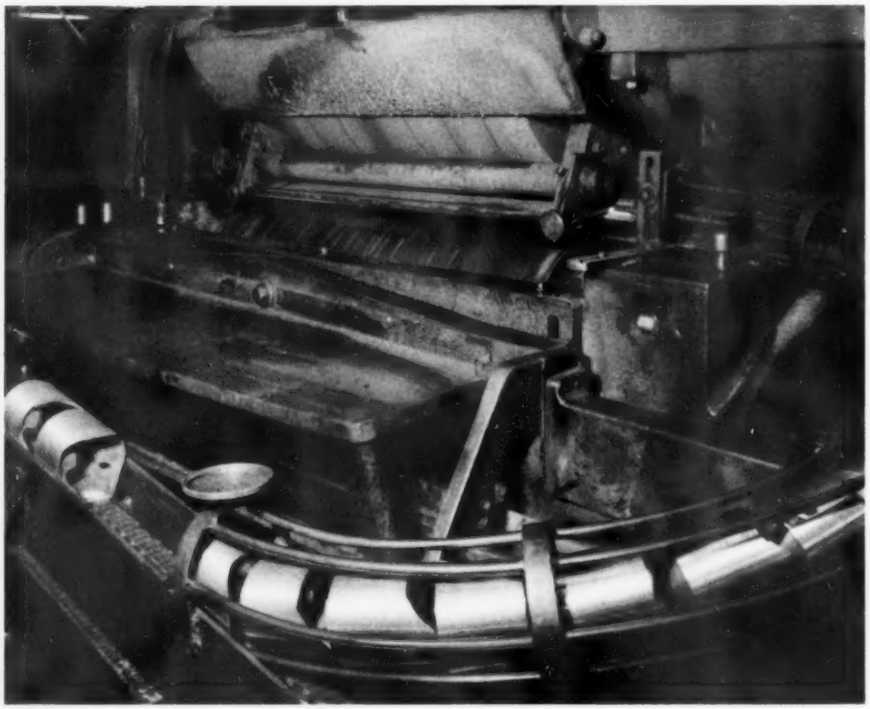
After annealing, pistons are rough and finish turned in an eight-spindle rotary Sundstrand machine. The castings are chucked internally, and the machining cycle is completed automatically except for loading and unloading

PISTONS

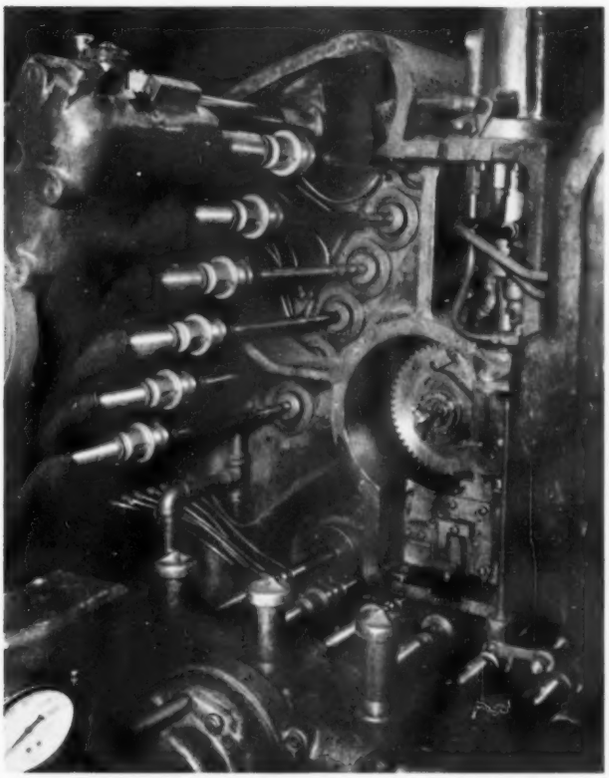
PISTONS are carried through the machining department on racks by a monorail conveyor. The tin-plating machine is also fully conveyorized to take the work through the various cleaning and plating tanks according to a predetermined time cycle.

The piston is made of chrome-nickel cast iron with a composition designed to give fine grain and long wear. It uses a dome-head construction with an 0.037-in. thick skirt, having an X-rib bracing to give added rigidity.

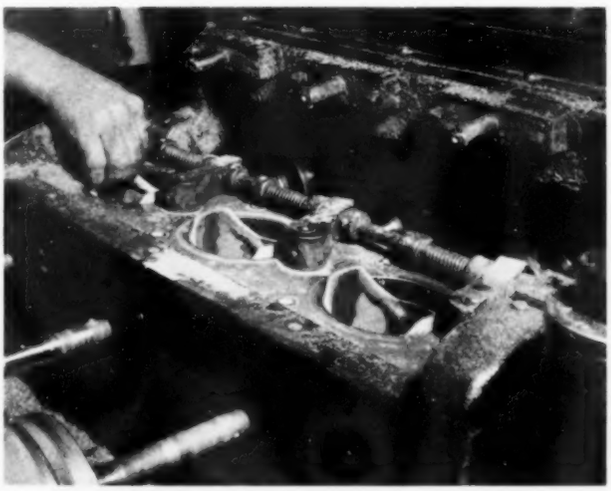
Piston diameters are rough ground on a Cincinnati No. 5 centerless. The operator removes the work from the monorail and feeds the machine through a special wire chute. As the pieces come out at the other end, they enter another chute and are elevated by a chain conveyor back to the operating position for their return to the monorail



The dome and flat are finish turned, and the ring grooves rough turned in a Goss & DeLeeuw five-station chucking machine. The cuts are taken with form tools

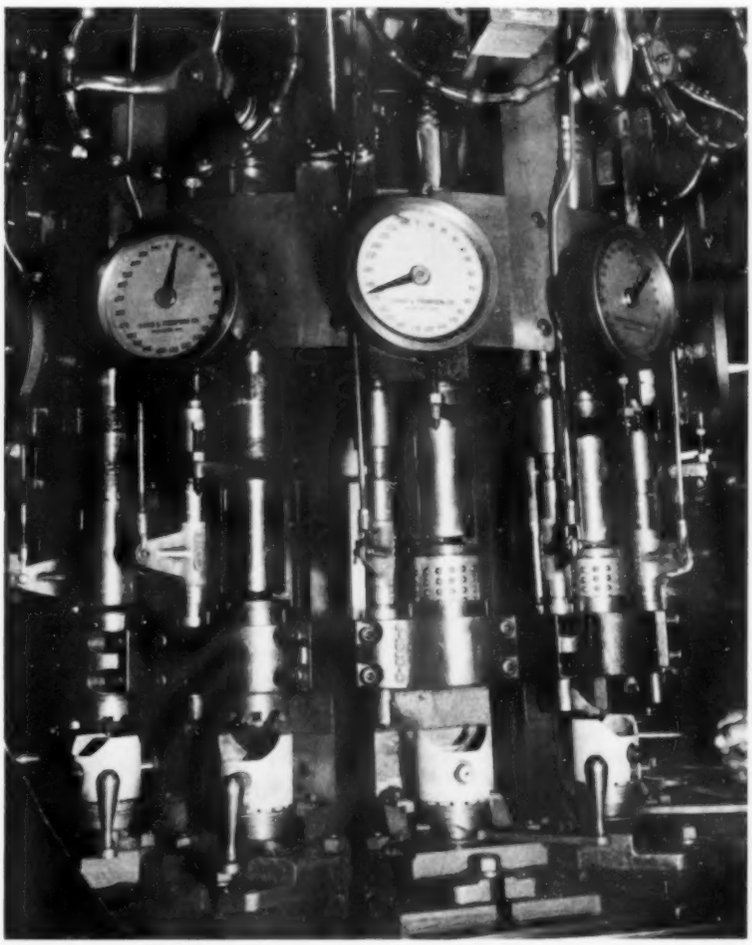


Wristpin holes are first bored from both ends and then line bored from one end in a three-station Barnes drum-type machine. Six pistons are chucked simultaneously in the loading position



After the pistons have been bushed and plated, the pin holes are diamond bored. The work is done in a six-spindle Ex-Cell-O which takes three pieces at a time and bores from both ends at the same time

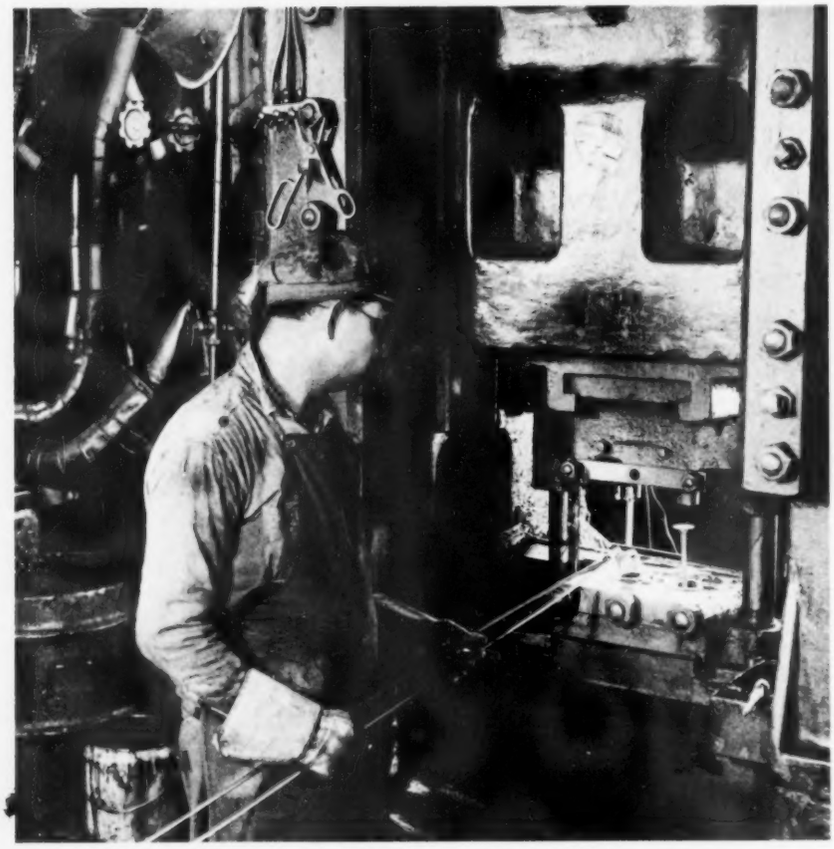
When the pistons are sorted for balance in a Toledo scale, they are machined as required in a Davis & Thompson rotary machine. A milling cut is taken from the bottom of the skirt to obtain the desired weight



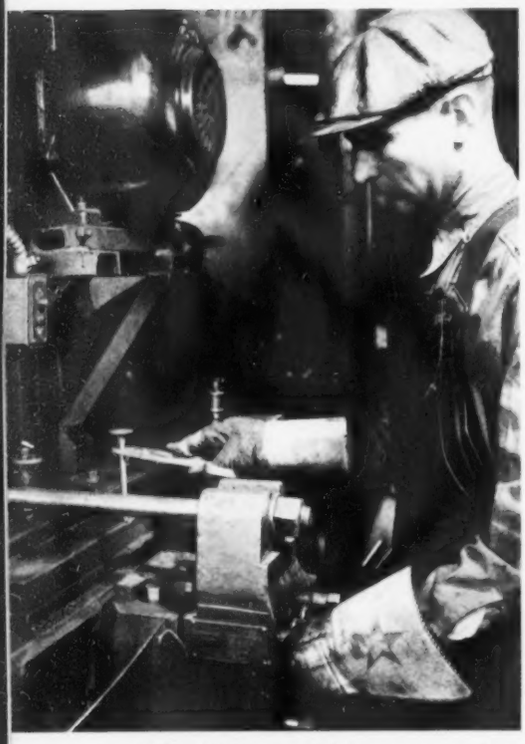
VALVES

CHEVROLET VALVES are made from round bar stock, 1¼ in. diameter for the intake valve and 1⅛ in. for the exhaust valve. A high chrome-silicon steel is used (Cr. 8.00-10.00; Si. 3.00-3.80). Operations consist chiefly in hot forming the blank and grinding it to size. The only cutting operation is in machining the key grooves and chamfering the stems.

After forming has been completed the work travels along a roller conveyor in tote boxes. Machines on either side of the conveyor perform the grinding and other operations. Valve heads are stamped *IN* and *EX* so the operators may readily distinguish between intake and exhaust valves.



Hot valve slugs are placed in the left-hand recess of a double die block where they are extruded to shape; the blank is then transferred to the right-hand recess for coining. One valve is completed with each stroke and is dropped to an underfloor conveyor at the back of the machine to be carried to the straightening operation

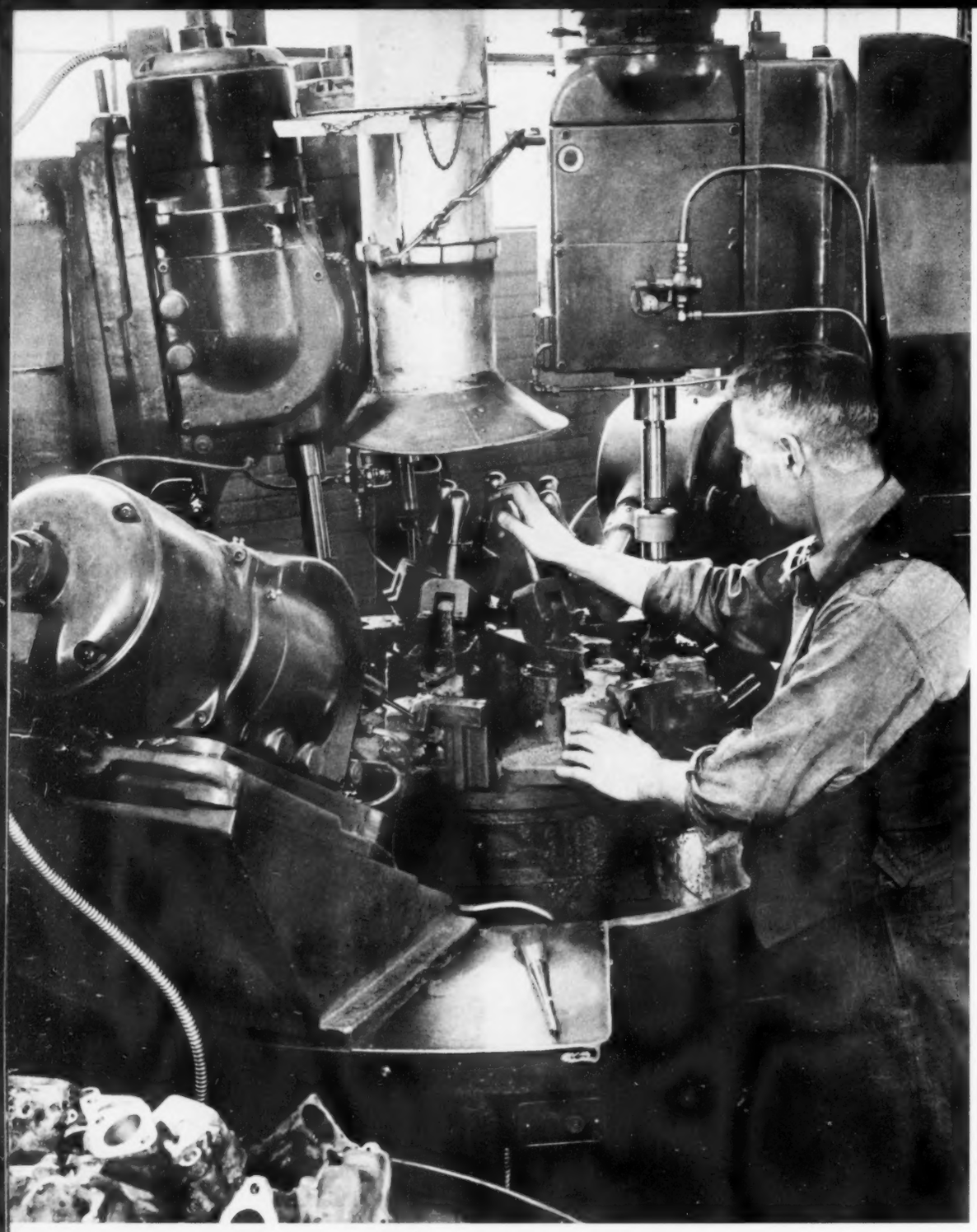


Valve blanks carried by conveyor from the extruding press are fed while still hot into a Waterbury Farrell rolling machine to straighten the stem. A small electric furnace is available for those pieces that need reheating

This merry-go-'round arrangement built by Gardner grinds valve stems to length. The operator drops the blanks into recesses where they are clamped by a cam-operated mechanism during the grinding process. The clamps unlock automatically and the valve is raised for easy removal

A Cincinnati grinder with a beveled wheel grinds the valve seats. The blank is chucked pneumatically, sized automatically and ejected by a kick-out when the operation is entirely finished

Valves are inspected for stem size, length and position of the key grooves. Limit gages on either side are used for checking the diameter. For the length test only one dial indicator is used to give a 50 per cent inspection in this dimension



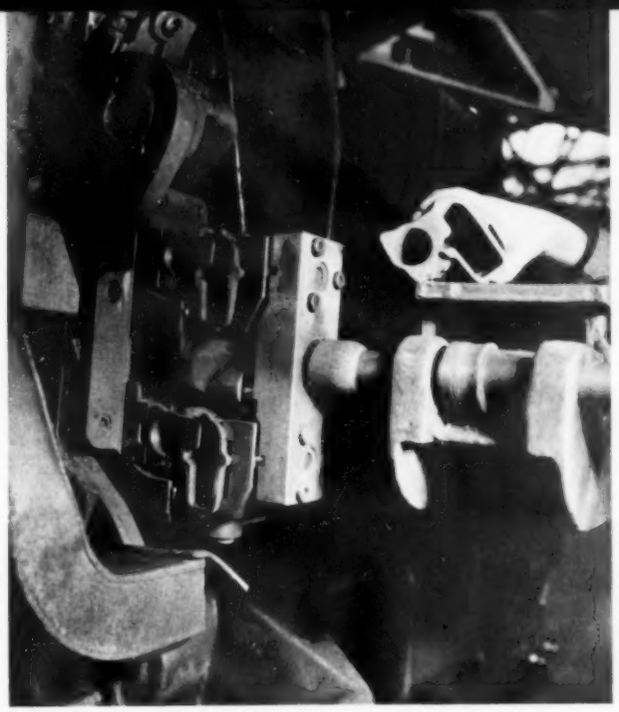
The body goes through a series of eight indexing Kingsbury machines each designed to complete a series of holes. A close view of one of them shows a typical set-up. The seventh in the series, this particular machine performs a cycle of counterboring and reaming operations

CARBURETOR BODY

THE BAY CITY plant supplies small parts of many kinds to the other Chevrolet manufacturing units. Most of the other divisions are dependent on Bay City for something or other, be it in the form of separate parts, sub-assemblies or complete assemblies.

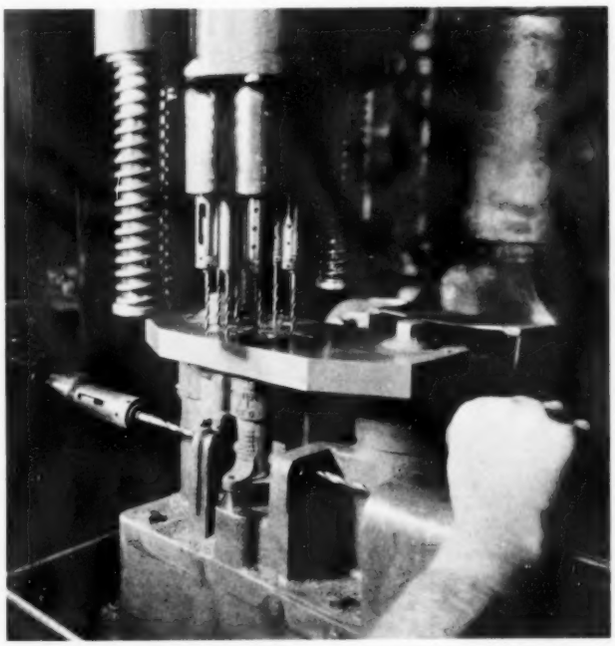
Bay City's output consists entirely of small parts which run into great variety and large quantities. To mention only a few of thousands of items, the plant produces carburetors, drag links, tappets, push rods, piston pins, screws, bolts and pins of all sizes and shapes, other screw machine parts and die castings.

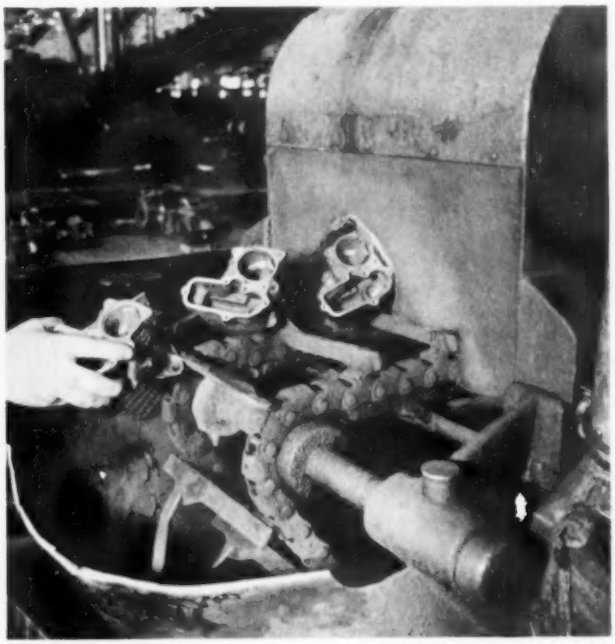
There are some 350 screw machines and 28 die casting machines at Bay City. The plant organization is set up so each foreman has complete charge of an individual item from start to finish. This arrangement eliminates any chance of passing the buck on quality or on meeting delivery dates because of delay in the receipt of parts from other departments.



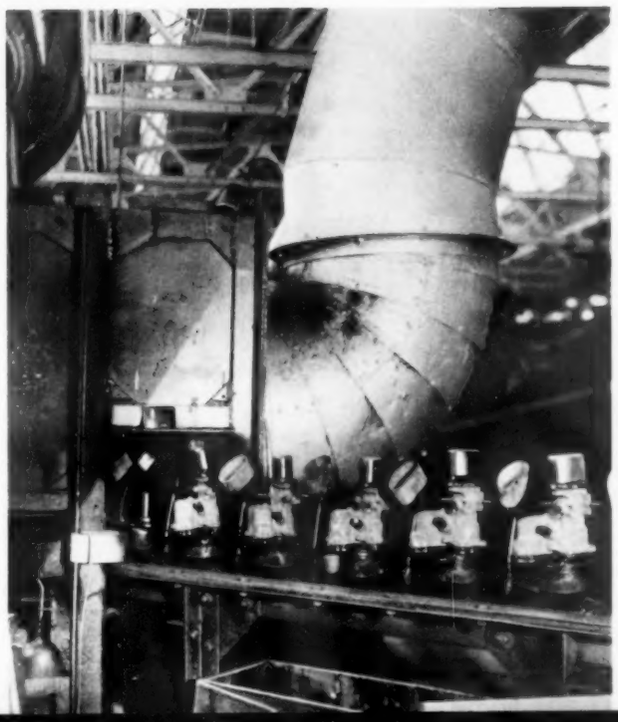
Carburetor bodies are made of nickel cast iron. The castings are Parkerized and then go to the first machining operation in a trunnion type Footburt drilling and milling machine. Here the throttle bore is roughed and finished; the horn end and venturi radius is bored and reamed. Parts are chucked two at a time, indexed automatically and worked upon by hydraulically fed units. The clamping wrench is arranged so the machine cannot start until it is removed from the work

With the machine work completed, the casting is blown out and put through a conveyorized Niagara washing machine. At Bay City, as at other Chevrolet plants, cleaning is a mechanized process taking its logical place in the sequence of operations





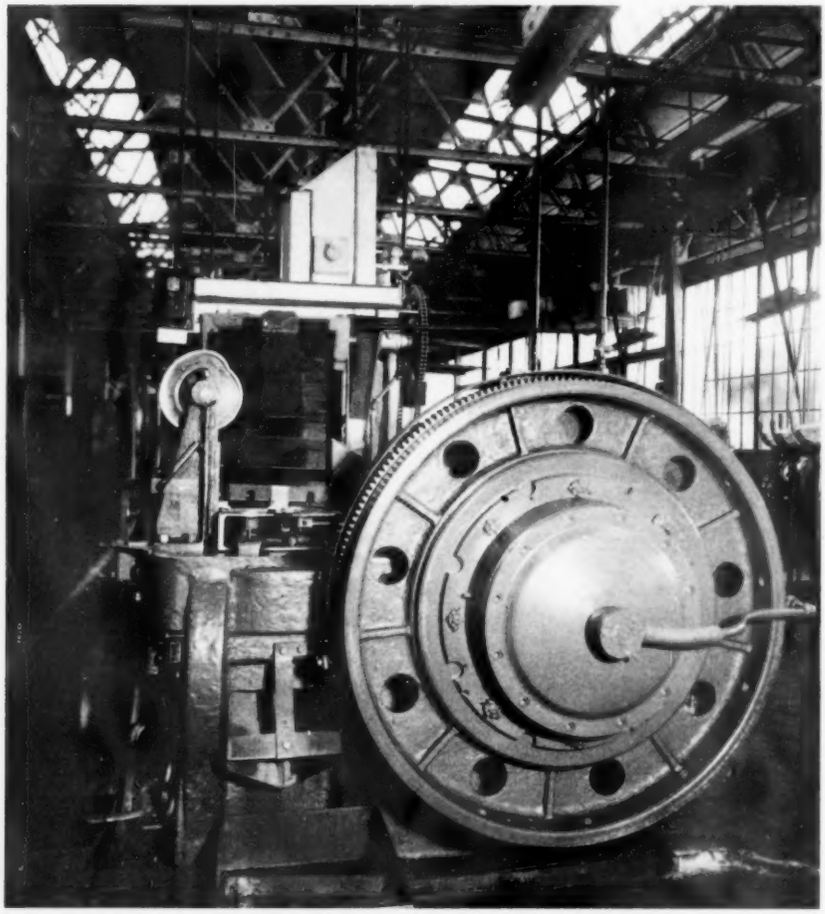
From the first operation the bodies are carried to the next on a monorail conveyor which serves to cool them after the intensive machine process. Located from the top and bottom bores and one of the flange holes, the work is chucked in a five-way Kingsbury machine to drill the seven cover holes and other miscellaneous holes



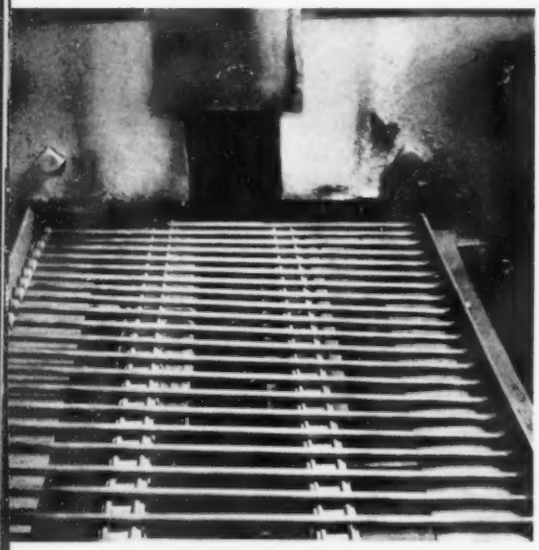
Jet bushings and eight rivets are added after which all holes are plugged while the body is painted. A chain conveyor carries the body together with two carburetor covers through the spray booth and an air drier. The covers are sprayed twice, once inside and once outside, and hence have to travel through the booth a second time

PUSH RODS

PUSHRODS are of 1035 steel cut to length in Brown & Sharpe automatics. A hot upsetting process is used for forming the ends. The rods are lifted first on an air hoist where they are washed free of grease and carried automatically through along a gas-fired Surface Combustion furnace which heats one end to forging heat.



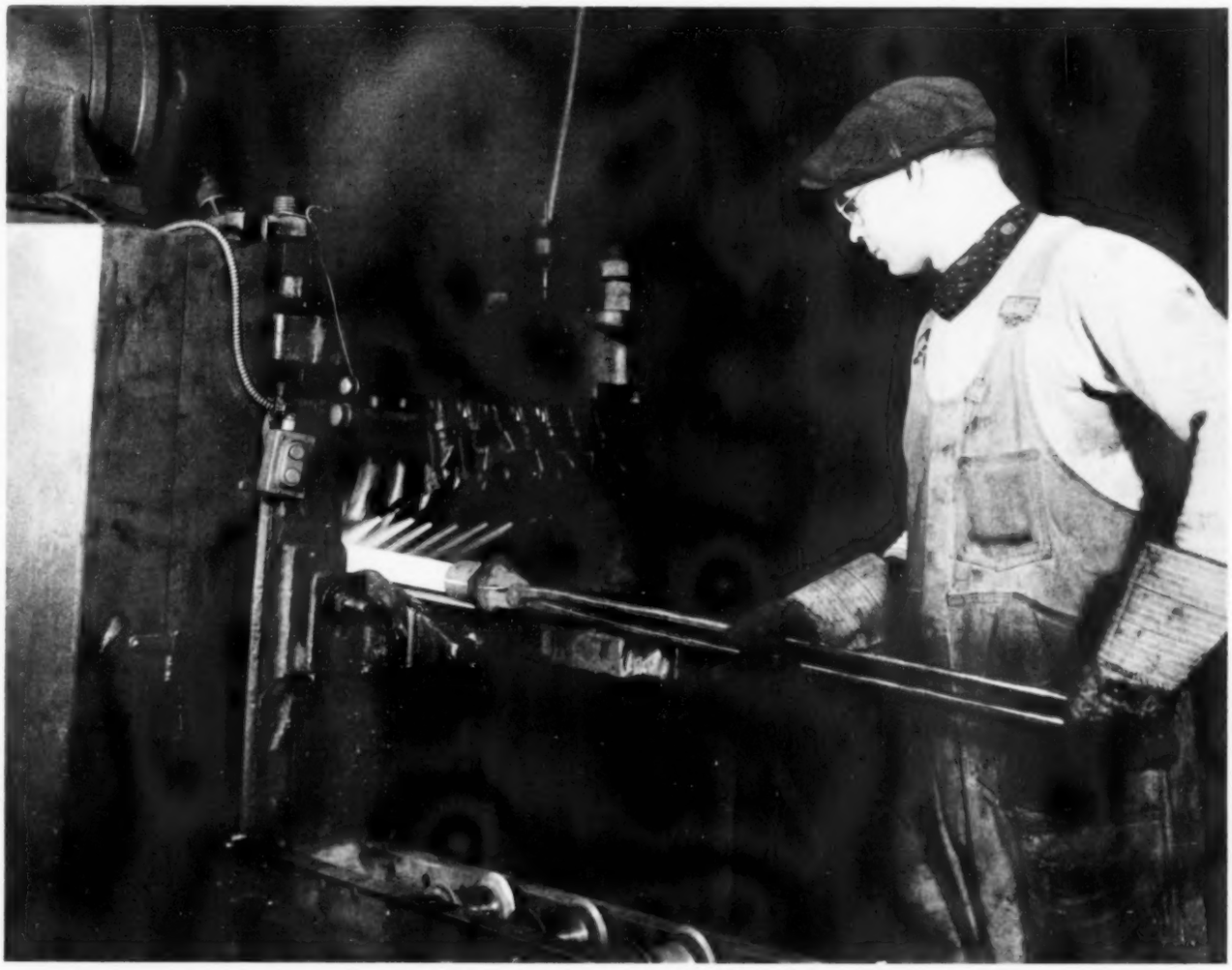
After being heated, pushrods roll down an interrupted incline to a National upsetting machine equipped with an opening die that forms the end in three steps. The rod drops from one die position to the next so one is completed at each stroke. As the ball end is done first, the rod passes through another furnace and another upsetter to complete the socket end



Pushrods are heat-treated in another Surface Combustion furnace, open at the center, which heats the ends simultaneously. A chain feed carries the work along until it is dumped into a water quench at the discharge end of the furnace. The water is circulated to maintain a uniform cooling temperature

To clean the ends of the rods an automatic sand-blasting machine has been built. Rods are fed down an incline to the first station where one end is sand blasted and then to a second station where the other end is cleaned from a nozzle on the opposite side. Friction rolls rotate the pieces at both stations. Upon coming out of the machine the rods are ready for final inspection and shipment

FORGINGS



Hot rear-axle shaft blanks are delivered to Ajax roll-forging stands where ten passes through the rolls elongate the shaft from 21 to 36 in. and leave a large section at each end of the blank. Succeeding operations finish size each shaft and upset the flange at one end

PARTS MADE UNDER THE HAMMER

FORGED STEEL parts, including such items as the crankshaft, rear axle shaft and hypoid drive gear and pinion are made by the Chevrolet Forge Division which, in reality, is more than a forge shop. Located in Detroit, it consists not only of one of the world's largest forge plants, but also of a spring and bumper plant which produces leaf springs, coil springs for the front wheel suspension assembly and bumpers.

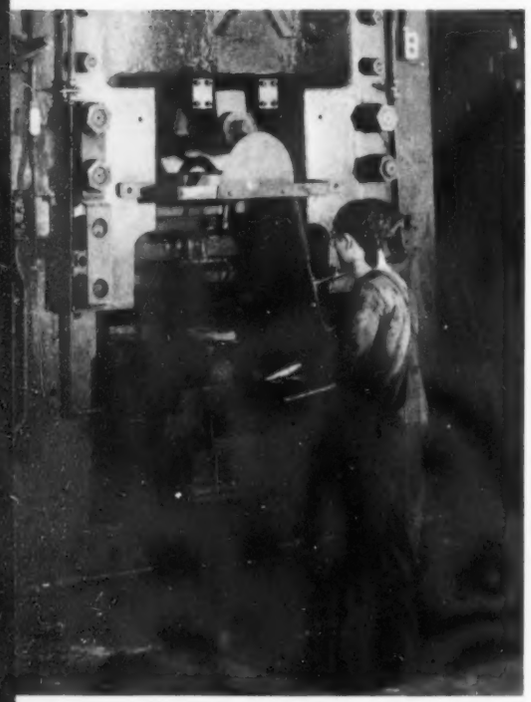
The impressive size of this division is indicated by its normal employment of about 4,000 men and by the large amount of equipment in use. Two forge shops are equipped with 131 hammers, 29 upsetters, 172 presses and 203 furnaces. The spring and bumper plant has 49 furnaces and 70 presses.

In a typical month the division turns out over 9,500,000 forgings ranging in size from ¼ to 87 lb. During an average day 25 carloads of steel come into the plant, are unloaded and piled into numbered bins. Within a single calendar year the material consumed in this huge factory runs into high figures: 12,500,000 gallons of fuel oil, 420,000,000 cu. ft. of gas, 533,000,000 lb. of steel and over 4,000,000 lb. of concentrated sulphuric acid (for pickling operations).

Every bit of material must be of the proper analysis. Samples of steel, for example, are taken from each lot shipped in and are tested in the laboratory to see that they have the right characteristics and quality for the part specified. After approval by the laboratory, the steel is sheared to the proper length to form the part. Some of the shears have capacity to cut alloy steel bars more than 4 in. square. Practically all of the sheared blanks are transferred by electric trucks in

Most forgings are cold trimmed in press lines placed on both sides of a continuously operating slat-type conveyor line in one of the large aisles. A number of special trimming and straightening tools have been developed for this line, the one shown being used for straightening and coining a small forging. This tool permits continuous operation of the press

Less than one minute is required to transform a hot billet into a forged crankshaft. Forging dies weigh 9,200 lb. and can make up to 75,000 crankshafts



Blanks for truck and passenger car hypoid ring gears are press forged in a three impression die. Each press group can produce 105 ring gear blanks per hour, a considerable increase over previous methods. These blanks are hot-trimmed in a second press near by

boxes or racks to the forging furnaces. These furnaces are heated by oil or gas to a temperature of approximately 2,300 F.

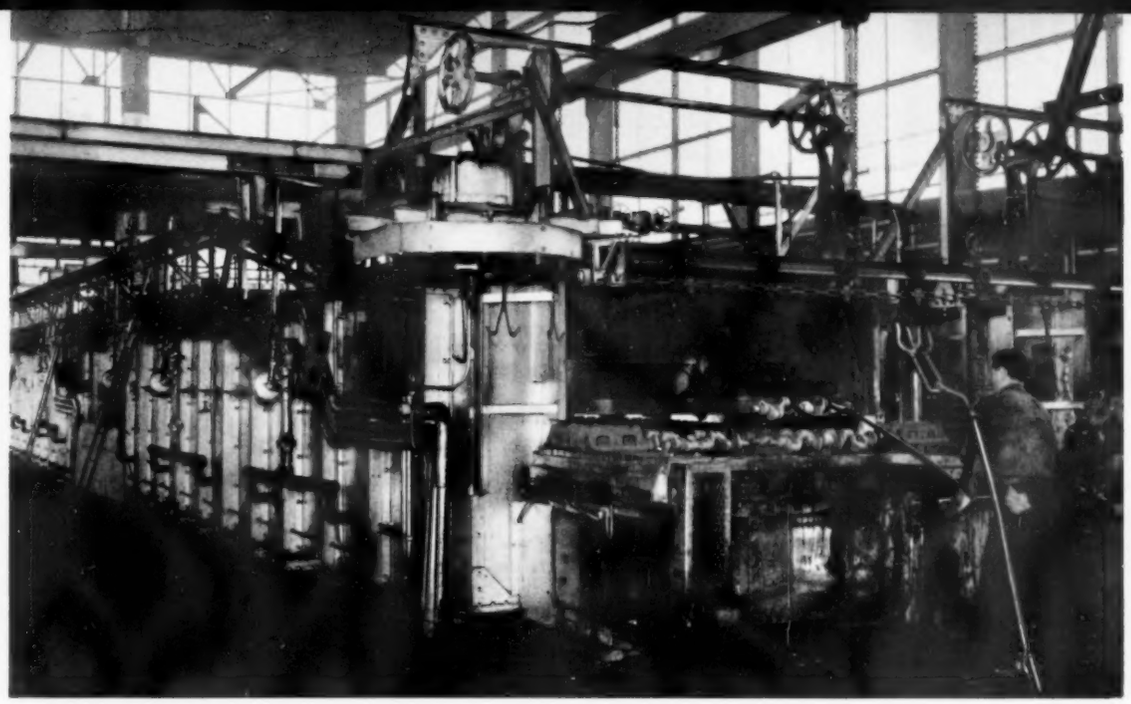
The use of presses for forging operations is increasing rapidly; the machines used are able to exert a pressure of from 600 to 1,800 tons on the forging. In this operation, after one or two preliminary blows in separate impressions, the steel is pressed between two finishing dies and the surplus metal squeezed out in the form of flash. Ring gears for the rear-end assembly are press-forged in three operations, using a three-impression die in one press. There are two breakdowns and one finish operation. These blanks are hot trimmed in a second press, and 105 ring gears per hour can be obtained from each group.

Drive pinions for truck and passenger car rear ends are forged at the rate of 150 per hr. in a 4-in. upsetter using a five-impression die with considerable gather in the first impression. In this set-up, the tongs used for handling the blank are arranged to lock the stock in the first impression of the forging die and are specially designed to include a projection which mates with a depression in the die block. This not only serves to lock the blank in position, but prevents tongs being knocked out of the die during the operation.

Rear axle shafts are produced in a set-up which is quite different from other forging operations in the plant. After shearing, the stock is delivered to forging furnaces by means of a conveyor. Hot blanks are rolled in grooves in Ajax roll forging machines. Ten passes in the rolls lengthen the stock from 21 to 36 in. and, at the same time, form the shafts to the right size and shape. Shafts then are placed on a conveyor which delivers them to a steam hammer for finish forging. Another conveyor carries them from the forging hammer to a press where ends are trimmed to proper length. Shafts then are allowed to cool on a conveyor which delivers them to furnaces where the large ends are heated for upsetting. Four operations in the largest upsetters in the shop, weighing approximately 25,000 lb. each, form 6⅞-in. diameter flanges on one end of these axle shafts.

A large portion of the forgings are shipped after being trimmed and inspected. Others must be heat-treated before shipment, and the forge shop is equipped with 23 furnaces for this purpose. Temperatures are held constant by automatic control equipment. Heat-treated forgings are pickled to remove scale in one of two straight-line pickling machines. Forgings are discharged from the heat-treat furnaces directly into acid-resisting metal baskets. These are loaded in the pickling machines by small overhead cranes. Baskets are carried through acid and rinse tanks in the pickling machine and are delivered to an unloading position. These pickling machines, specially designed for this application, are carefully hooded to prevent the escape of fumes into the work area and parts are handled only after they have been rinsed free of all acid.

Burrs left after the flash has been trimmed are, in some cases, removed by grinding as are certain spots on



Finish forged crankshafts are heat-treated in one of two automatic furnaces having heating, quenching and drawing divisions. Hardened and drawn crankshafts are transferred to an automatic pickling unit

other forgings. The grinding stands are fitted with dust-collecting hoods connected to a central collection system. The inspection department checks all parts to insure that they are made to proper size and shape, special care being taken to check forgings for seams, cold shuts, laps and similar defects. Shipping department counts and loads approximately 21 carloads of forgings and five carloads of flash and tong holds each working day.

FORGED CRANKSHAFTS

ARRANGED especially for the production of the six-cylinder Chevrolet crankshaft, forge plant No. 2 is equipped to make that operation as efficient as possible. The steel, as usually used, is received as billets in bundles of 25 pieces. These bundles are stored in the steel yard until approved by the laboratory, then they are loaded on a monorail conveyor and delivered to the billet heating furnace of one of the six forging units. Every effort is made to handle these billets mechanically, since they weigh approximately 120 lb. each.

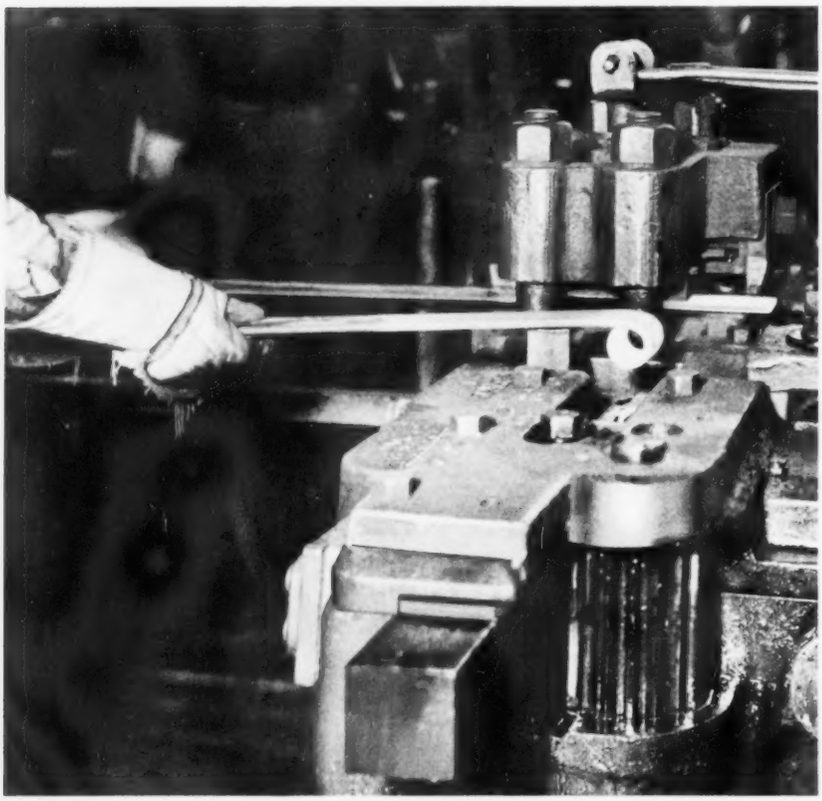
Billets are transferred from the conveyor to a roller loading table at each of the billet furnaces by an air hoist equipped with tongs. They then are rolled into position in front of the pneumatic pusher which feeds them into the furnace as hot billets are removed at the other end. Approximately 42 min. are required to heat the billet to a forging temperature of 2,200 F. Hot billets are supported from an overhead track on their way to the forging hammers. There, less than a minute is required for the hammers to forge a crankshaft.

Each crankshaft forging group includes a pusher-type automatic furnace, a 12,000-lb. steam hammer, a No. 59½ Toledo crank press for flash trim, a 4-in. Ajax upsetter for forging the coupling end and a 5,000-lb. steam hammer for the restrike operation. A set of forging dies for a crankshaft weighs 9,200 lb. and from 23,000 to 25,000 cranks are forged per sinking. Each die is resunk twice during its life. These are three-operation dies and include a roller, edger and finisher position.

After forging, the crankshafts are carried to the hot-trim press by overhead conveyor. There, the flash and tong holds are sheared from the shaft and separated. The trim press operator loads the flash and the tong holds on a power-operated conveyor which carries them outside the building. While the trim press operator is taking care of the flash, an upsetter operator removes the crankshaft from the back of the trim press and fits the flywheel end of the forging into an upsetting machine where the flange is formed in a single stroke. Crankshafts then are passed to the restrike hammer man who places them between the dies of a second steam hammer. These dies are designed to strike the bearings of the crankshafts to make them round and to correct any out of alignment which may have occurred during the trimming and upsetting operations. Crankshafts are restruck twice, the second blow being at right angles to the first. The next operator stamps the forgings with two marks, one indicating the sort of steel used and the other the hammer crew making the forging.

Forged crankshafts are heat-treated in an automatic furnace having an automatic quench arrangement between the hardening and drawing chambers. One man loads the forged crankshafts on alloy shoes on the pusher-type furnace bed. These furnaces are gas-fired and automatically controlled. Forgings are heated to a temperature of 1,550 F. for 65 min. and then quenched in water. They are then automatically pushed through the draw chamber where they are heated to 1,100 F. for 83 min. Drawn cranks are discharged on rails and are allowed to cool in the air for a few minutes before being loaded on a second overhead conveyor which carries them through an automatic pickling bath. After the pickling operation, cranks are carried by the same conveyor through an automatic grinding and Brinelling operation where photo-electric cells control wedges which hold the crank against a grinding wheel. This provides a spot for the Brinell test unit. The Brinelling unit automatically carries along the conveyor during the test operation and returns to its original position for the next crank. Approximately 400 cranks per hour can be put through this set up, which requires 4½ hr. for the complete sequence of operations.

SPRINGS



Leaves for Chevrolet springs move from operation to operation on one of two slat-type conveyors placed on opposite sides of the building. Loops are turned in each end of bottom leaves one at a time. Following the forming operation, each loop is sized

Hardened and formed spring leaves are sent through continuous draw furnaces, then dropped into water tanks for cool-

PROCESSED FOR SPECIFIED LOADS

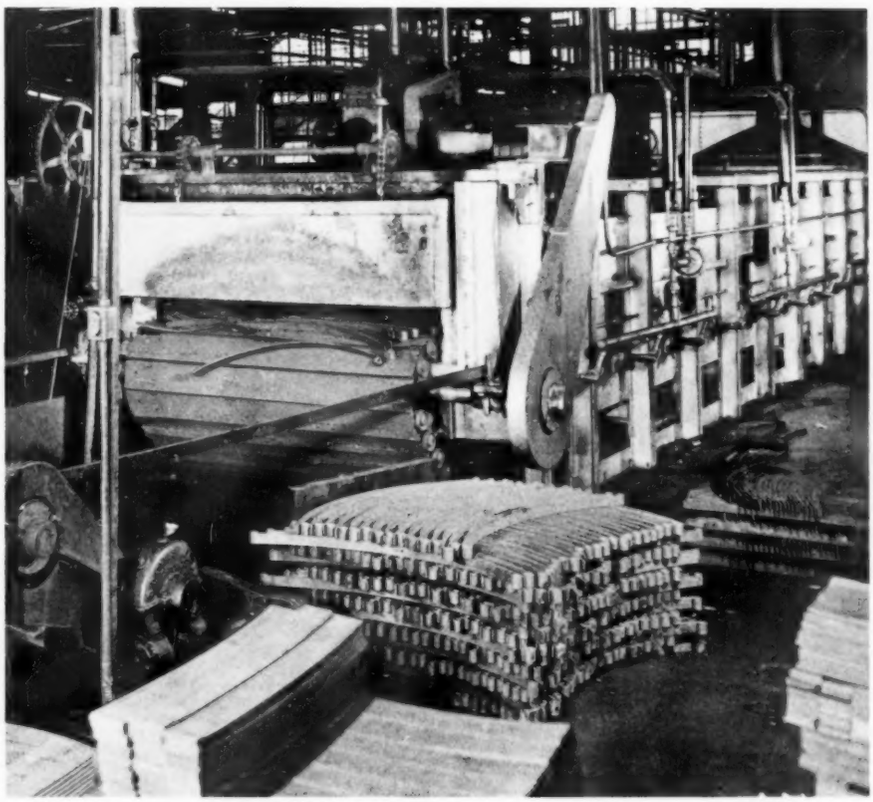
EQUIPPED to manufacture leaf springs for body suspension and coil springs for the front wheel suspension assembly, as well as all Chevrolet bumpers, the spring plant has conveyors and continuous-type furnaces so that the material moves progressively forward with a minimum amount of handling. All but the longest spring leaves are cut to length and the holes punched in a single operation on presses paralleling the main conveyor line. Leaves drop from the presses to the conveyor which carries them past intermediate operations to the hardening furnaces. Eyes on the long lower leaves are formed in a group which removes the leaves from the conveyor line, forms the eyes at each end and then returns the leaves to the conveyor.

Operators of specially designed hardening furnaces unload the stock conveyors and load the spring leaves into the furnaces according to prearranged schedules. At the discharge end of the hardening furnaces, the hot leaves are loaded in special quenching machines which form them and hold them in shape until cold. Different forms are used for the various leaves, in order to produce the shapes necessary to give the required characteristics to the finished springs. Hardened spring leaves are sent through draw furnaces and are cooled in water tanks. Then they are sorted and loaded on a flat conveyor according to schedule. Leaves for one spring may be made in several different furnace units and, as the stock conveyor passes each unit, leaves are added so that the spring leaves are properly grouped by the time the spring has reached the assembly position. Leaves requiring spring clips are riveted in place, then the leaves are returned to the conveyor.

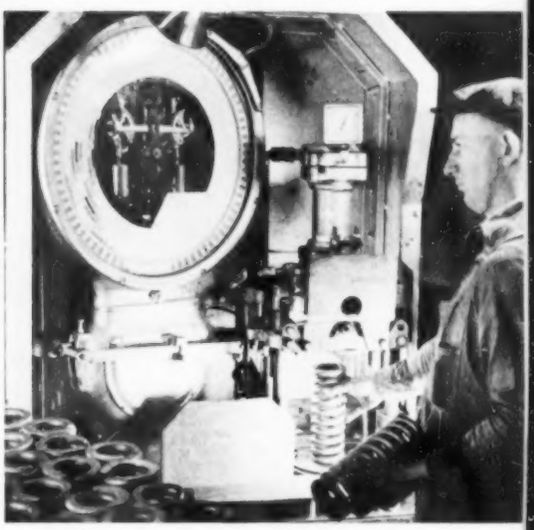
At the assembly position, leaves for a complete spring are transferred to a flat conveyor and sprayed with a special lubricant. After bolting the leaves together, spring clips are assembled and holes in the spring eyes checked to see that they are of proper diameter. Springs are given a distinguishing paint mark, since this plant makes 14 different leaf springs for the current Chevrolet models in addition to 44 springs for previous models. Finished springs pass to an inspection position where they are bent inside out and then tested to see that they carry the proper load.

Round bars, each long enough to make one outer coil spring for knee-action units, are received in bundles. These bars are first ground to correct diameter in centerless grinding ma-

Coiled outer springs for wheel suspension units are heated to 1,500 F., then placed in a special, multiple-station quenching press where each spring is held in clamps to proper length. Later the springs are drawn in another furnace, then checked for hardness. Scale is removed by shot blasting before final inspection of the springs



ing. These leaves are sorted and placed on the assembly conveyor according to a definite pre-planned production schedule



Each coil spring is carefully checked for inside and outside diameter, square ends, straightness, stiffness and height, both free and under load. All springs then are visually inspected for defects that might escape the other tests

chines and then heated on both ends. These ends are rolled to a flat point so as to form the end coils of the spring. At this point, the bars are more than 8 ft. long. Pointed bars are heated in a gas-fired furnace to approximately 1,500 F. and then coiled on arbors to form springs approximately 10 in. long and 3½ in. in diameter.

After cooling, on a conveyor, both ends of the springs are broached to give them the flat end bearing surfaces required. Springs then are checked and, if correct, are loaded in hardening furnaces where they are heated to 1,500 F. Hot springs are placed in a special quenching press which is designed to hold them straight and to the proper length during the quenching and hardening operation. After quenching, the springs are drawn in another furnace, cooled and delivered to a Brinell machine operator who checks the hardness of each spring.

Heat-treating scale is removed by shot blast, and a conveyor delivers the finished springs to bins at the inspection bench. Here each spring is inspected for inside and outside diameter, straightness, square ends, stiffness and height, both free and under load. These springs also receive a thorough visual inspection.

Manufacture of inner coil springs for knee-action units is quite different from that of the outer springs. The steel wire, which is approximately 7/16 in. in diameter, comes in coils weighing 150-200 lb. After approval by the laboratory, this stock is wound cold on an arbor into a coil spring approximately 2 in. outside diameter and 10 ft. long. A press is used to cut the long spring into short lengths, which are loaded into a furnace and heated to 1,500 F. As the hot springs are discharged from the end of the furnace, one at a time, an operator puts them in a press where the ends are squeezed together to form the end coils. He then loads them in baskets on a conveyor to cool.

This conveyor delivers the springs to broaches, where the ends are cut flat and square. From the broaching machines, these springs go to a hardening furnace and then through quench, draw and cooling operations. Another conveyor then delivers the cool springs to an inspector who checks hardness with a Brinell machine. Both ends then are ground square and to length and the springs are shot blasted, ready for final inspection. Practically the same inspection is given the inner coil springs as the outer units.

BUMPERS

Formed, hardened and quenched bumper bars are delivered by conveyor to the polishing room where two continuous multiple-head polishers finish all but the edges and ends of each bar

Polished bumper bars are delivered by conveyor to a continuous plating machine which washes, copper plates and nickel plates each bar. Bars are carefully inspected before plating

FORMED BRACKETS AND BARS

STEEL STRIPS for bumper brackets are cut to length in a press, then heat-treated, bent edgewise and punched. The press operator places the brackets on one of the main stock conveyors which delivers them to the heat-treating furnaces. There, they are loaded in the furnace and formed in hydraulic machines. These machines drop the hot formed brackets into oil-quenched tanks, where they are hardened. Conveyors carry them from the quench tanks to draw furnaces, through the furnaces to cooling tanks, and finally deliver them to an inspection bench.

Bumper bars are blanked and some of the holes punched in a single operation. Blanks then are heated in a special furnace and formed in a second press. The rest of the holes are punched after forming, since they would stretch out of shape and position on the bumper if punched during the first operation. The stock conveyor also carries these parts to hardening furnaces, where they are heated and quenched in forms. After drawing and cooling, they are inspected and straightened.

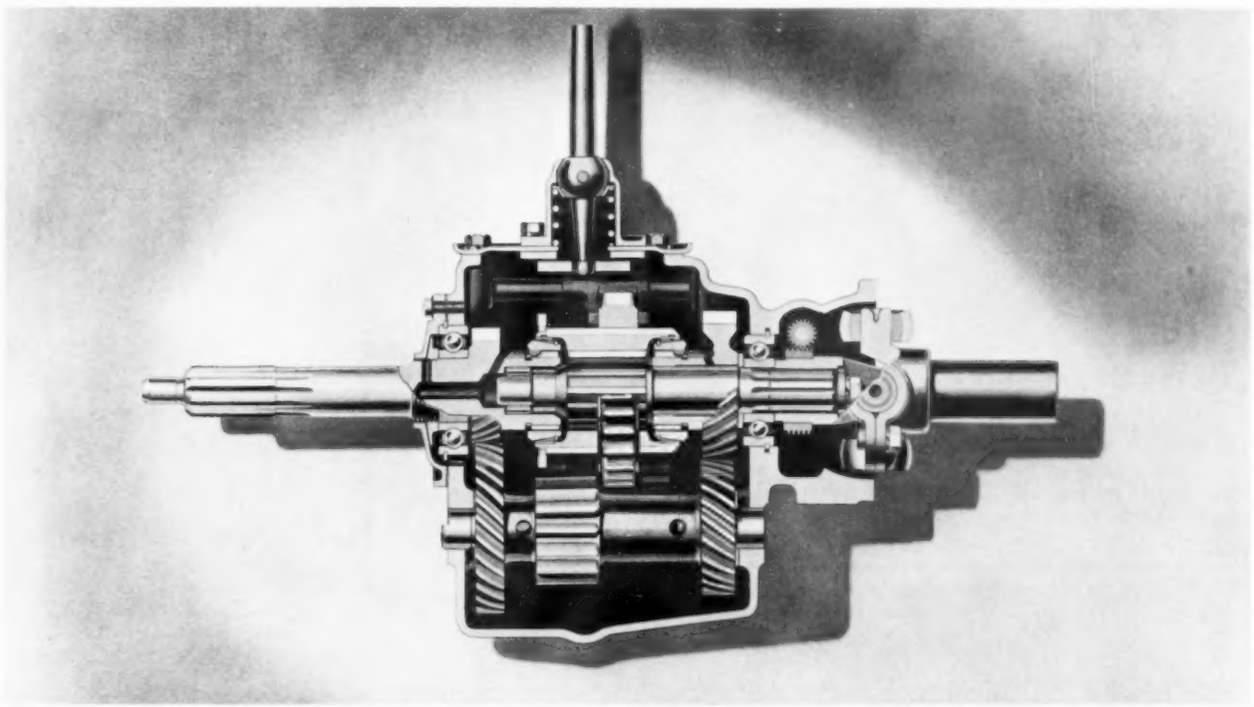
Bumper Finishing

Like the spring plant, the bumper plant has been laid out for continuous movement of material. Bumper material arriving from the spring plant is transferred to an automatic pickling machine where it is thoroughly cleaned. Material leaving the pickle bath is divided into two groups. Brackets are riveted together in pairs and loaded on a conveyor which carries them through a paint tank, a baking oven, and finally to the shipping department.

Bumper face bars are loaded on a conveyor which takes them to the four polishing machines, each with fourteen or fifteen wheels. Here, outside surfaces of the bars automatically are polished. Bumpers ride on a conveyor which carries them under these wheels. Bars become hot during polishing, so are hung on a slow-moving conveyor before passing through the second unit. Since the automatic machines cannot finish the ends and sides, bumper bars are delivered to a group of hand polishing lathes where workmen polish the remaining surfaces. Polished bars are carried by conveyor to an automatic nickel-plating machine which washes each bumper bar, deposits a heavy copper plate, a full finish nickel plate and delivers them at the unloading end of the machine 100 ft. away.

Nickel-plated bars then are delivered to an automatic buffing machine, which is similar to the polishing machine except that it only has four wheels. After this operation, the bars are inspected and delivered to hand buffing lathes where the edges and ends are finished. They then are carried by conveyor to an automatic chrome-plating unit, where they are washed, cleaned and given a bright chrome plate. Plating is tested by a salt spray. Bumper-bar backs are sprayed with an aluminum paint.

TRANSMISSION



Greater compactness of the synchronizing mechanism permits a better-supported, stiffer mainshaft, and lightening of the transmission by 22 lb.

A GEAR BOX BUILT TO BE QUIET

THE TRANSMISSION, like other parts of the Chevrolet car, is built to exacting requirements. Its manufacture is about evenly divided between two plants—Muncie, Indiana, and Saginaw, Michigan. Three types of transmissions are built — passenger car, commercial body and ½-ton truck. All three are made by the Chevrolet - Muncie Division, which was established in 1935, but only the passenger-car type is produced at Saginaw.

Production at the Muncie plant runs into hundreds of thousands of units per year, but a few additional facts and figures may aid in grasping the size of this enterprise.

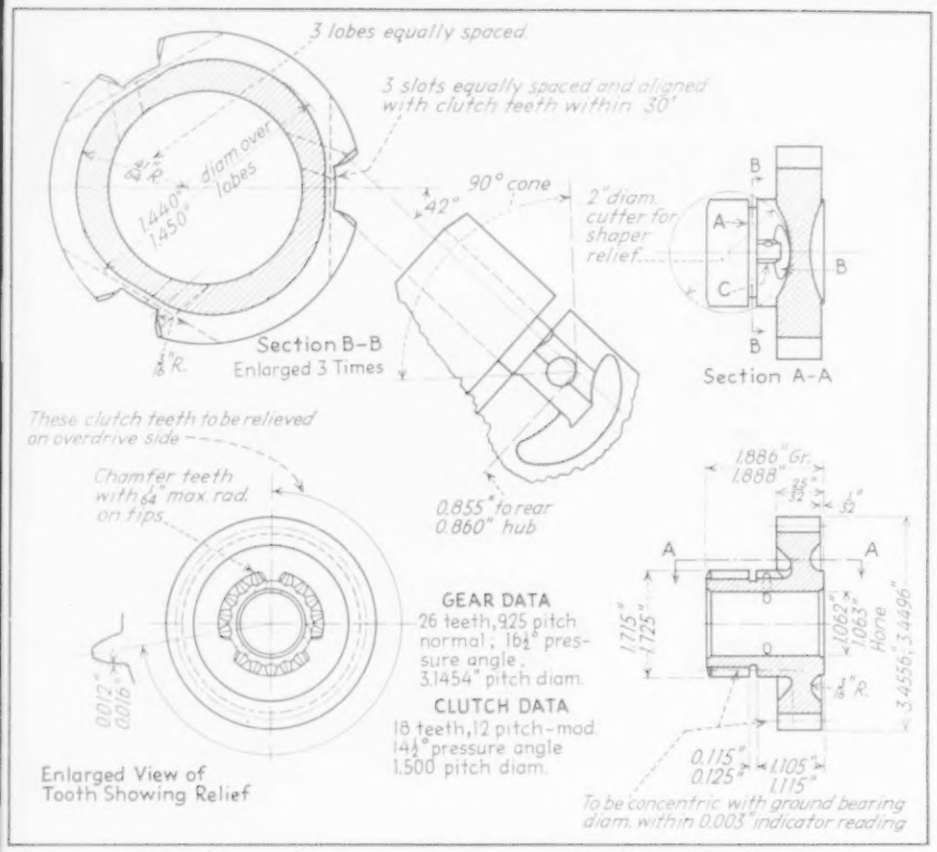
Fifteen hundred employees make three transmissions per minute. Approximately 50,000,000 lb. of steel are handled by the forge shop each year. On a single part alone — the countergear forging—more than 300,000 ft. of countershaft holes are drilled annually as one of the first operations on the piece. More oil is used in making a transmission than is used in the transmission in its entire life.

All machining is done in Plant No. 1, and all forging in Plant No. 2. The former is a long rectangular building with offices on the street and the heat-treating department at the far end, while the great bulk of the floor space is given over to machining and assembly of transmissions for passenger cars, commercial-body jobs and the ½-ton truck.

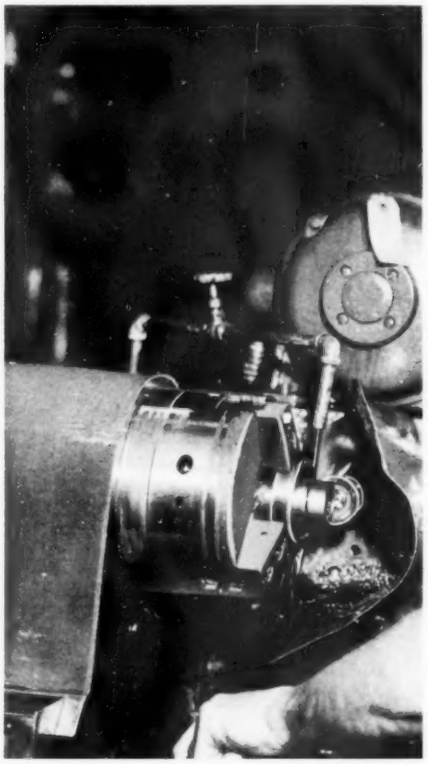
All passenger-car and commercial-car transmissions are built on one side of the long center aisle and all of the truck jobs on the other side. Material is delivered to the loading docks on the outside walls of the building and progresses through the various machining stages to the center aisle where the parts are picked up by the conveyor and taken to the heat-treat. The overhead chain conveyor goes down one side of the center aisle to take away green gears from the passenger car transmission lines to the heat-treat, and in returning from the heat-treat goes back up the center aisle on the other side to serve the truck transmission line. The conveyor transports closely spaced alloy fixtures, each of which is specially designed for the part it is to carry. In many cases the fixures go right into the heat-treat such as cyaniding, and must be made of a material to withstand such service with minimum deterioration.

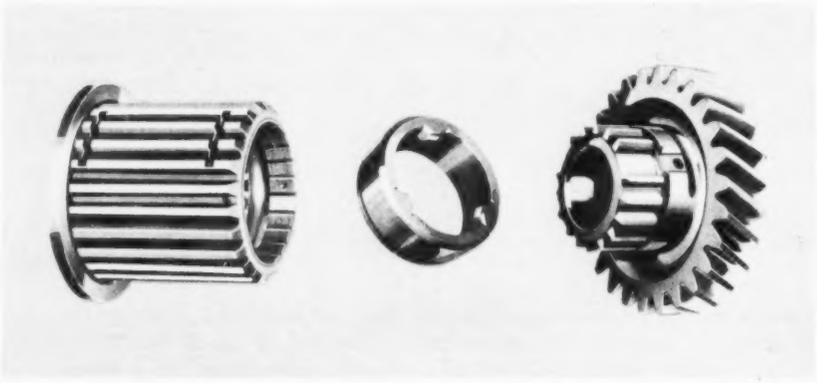
A second overhead chain conveyor runs crosswise in the building to serve the passenger-car and truck-transmission assembly departments. This conveyor takes the transmissions to a noise-testing room built into an extension of the roof and directly over one of the loading docks. Transmissions are removed here, noise-tested and again placed on the conveyor which drops them down to the loading platform.

Since there are 128 parts in one Chevrolet passenger-car transmission and 115 parts in the commercial truck

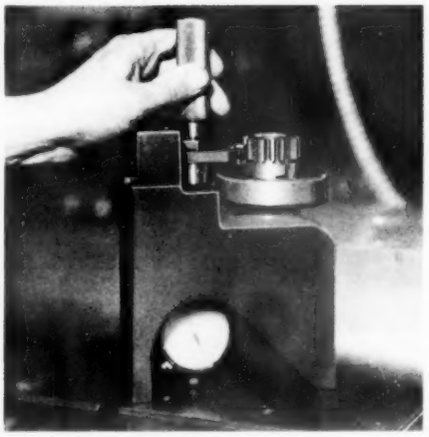

3 lobes equally spaced
3 slots equally spaced and aligned with clutch teeth within 30'
diam over lobes
1.440" 1.450"
90° cone
42°
2" diam. cutter for shaper relief
Section B-B Enlarged 3 Times
Section A-A
These clutch teeth to be relieved on overdrive side
Chamfer teeth with 1/64" max. rad. on tips
0.855" to rear 0.860" hub
1.886" Gr. 1.888"
GEAR DATA
26 teeth, .925 pitch normal; 16½° pressure angle; 3.1454" pitch diam.
CLUTCH DATA
18 teeth, 12 pitch-mod. 14½° pressure angle 1.500 pitch diam.
Enlarged View of Tooth Showing Relief
To be concentric with ground bearing diam. within 0.003" indicator reading

Clutch teeth and three synchronizing slots are cut in the second-speed gear





Essentials of the synchronizing mechanism are: the second and third speed clutch; the synchronizer ring (two required), and the second-speed gear



transmission, it is obviously impossible to cover all of the manufacturing and inspection operations in the Muncie plant. For this reason, three parts that comprise the heart of the passenger-car transmission have been selected for description of their manufacture and inspection from forging to assembly. These three parts — the second speed gear, the synchronizing rings and the second and third speed clutch — are the major pieces in the synchronizing assembly and reveal as advanced practices in manufacture as any that go into the transmission.

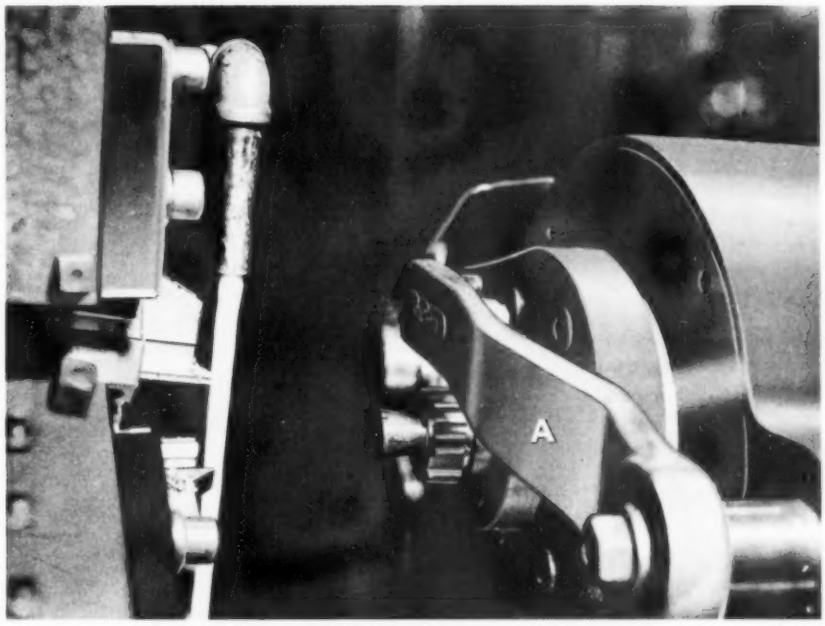
Another feature of the plant will be described in detail. It is an automatic carburizing set-up for truck gears which embodies new principles.

SECOND SPEED GEAR

ALTHOUGH the second speed gear could be drop forged, it is put on an Ajax 4-in. upsetter to secure greater refinement of the grain structure and a more desirable grain flow of metal to give better characteristics in the gear teeth. Upsetting is done at the rate of 150-175 pieces per hour. A 75-in. SAE 5145 bar makes fifteen forgings weighing 3.58 lb. each. The four operations on the upsetter consists of forging a cone shape on the heated bar end, semi-finishing in the second die impression, partly piercing and finishing in the third die, and finishing in the fourth impression. Snag grinding, annealing and removal of scale precede trucking of the second speed gear forgings to Plant No. 1.

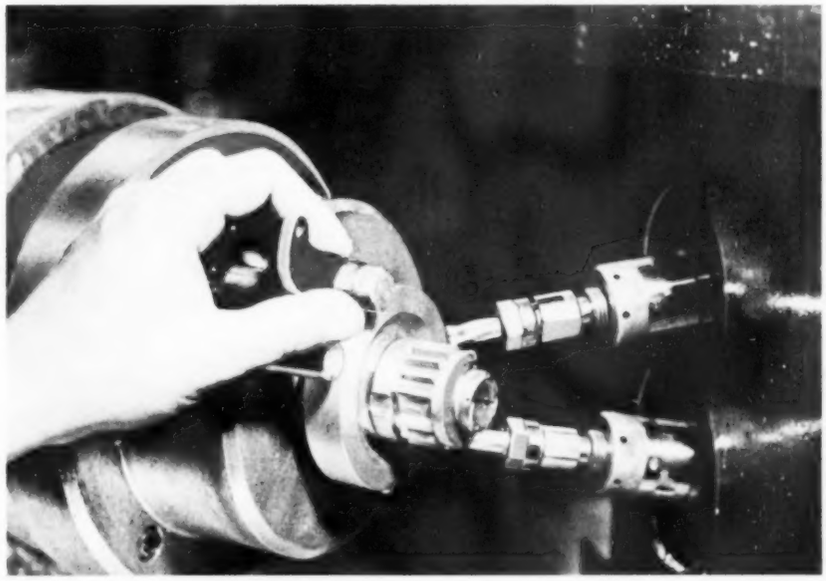
The forging is core drilled in a Defiance single-spindle drill, leaving 1/32 in. of stock for broaching. In one pass the combination pull broach, as used in a horizontal La Pointe, brings the hole to 0.001 in. from blueprint specifications. The operator inspects the broached piece with a plug gage. Most operators in the machining department are supplied with appropriate gages which are duplicates of ones used by the inspec-

Three relief slots are milled on this Cross machine, the slots giving clearance close to the large gear so that the synchronizer slots can later be cut



Three slots for the lugs on the synchronizer ring are shaped by a special Cross machine. The swinging arm *A* locates the gear from the gaps in the teeth, and the three tools then advance to cut the slots running into the relief slots

The forward edges of the synchronizer slots are chamfered on another special Cross machine. Ordinarily the shop works to a 0.003 in. limit from the apex of the chamfer to the back face, although the drawing calls for 0.005 in.



Testing the height of the chamfer is done with a box fixture. A conical point on a gage fits down into the chamfer in the synchronizer ring slot, and error is shown by the dial indicator

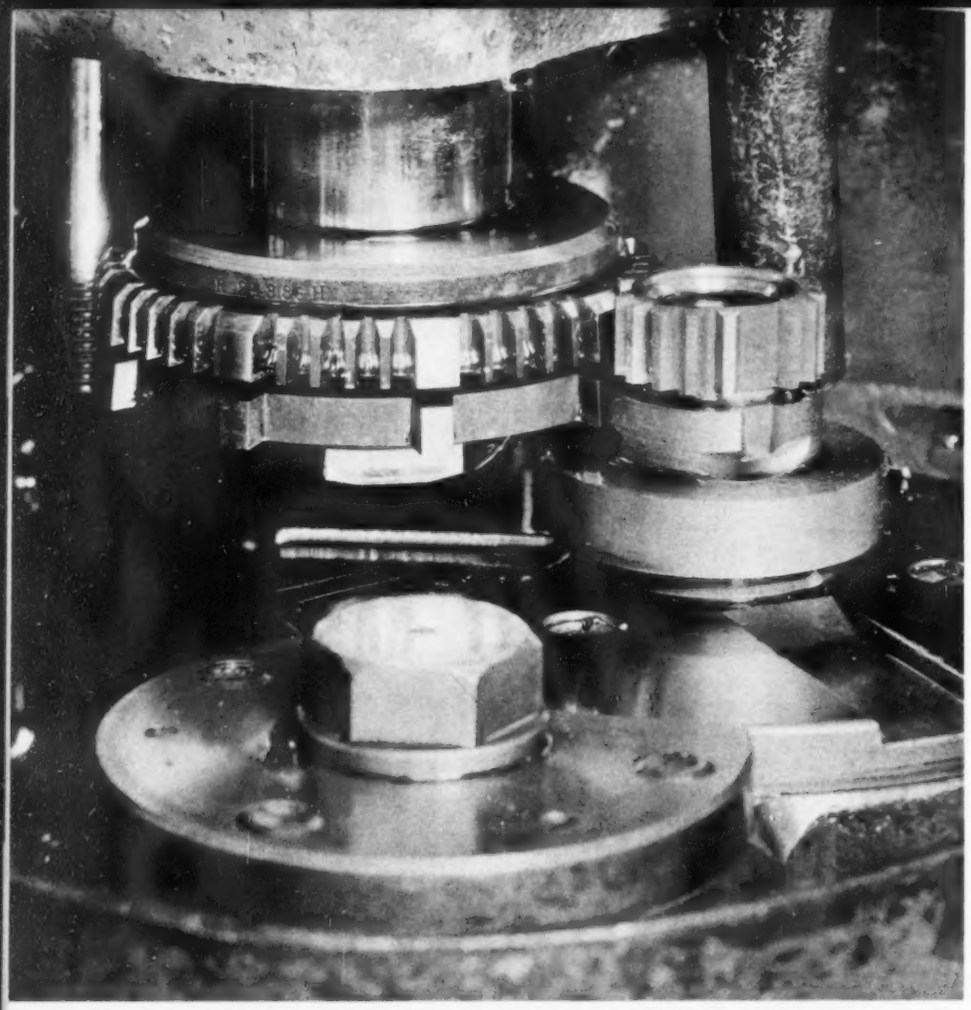
tion force, and this practice contributes much to the accuracy of the product.

Broached forgings are passed to two 24-in. Cincinnati upright drills for chamfering and spot facing both sides, using cobalt-steel cutters. The gear end (large end) is then turned complete on a Fay automatic; that is, turning the O.D., cutting the 3/16-in. radius channel and facing the end. Another Fay turns the clutch end and roughs the synchronizing ring groove *A*. Three relief slots *B* are then cut in a special Cross machine to give clearance when cutting the three lengthwise synchronizing slots *C*.

Perhaps the first really important operation from the standpoint of how its accuracy will affect subsequent operations is now performed in a Porter-Cable lathe equipped with an air chuck. Here the second-speed gear blank is qualify faced (to establish subsequent locating surfaces) on both ends. Both front and back tool blocks are used, and the work is held on an expanding mandrel. Note that the synchronizing ring slot is not finished in this operation.

Accuracy of the succeeding operation is likewise important as it bears on the correct timing of engagement of the second and third speed clutch. The operation consists of turning the bottom of the synchronizing ring slot like a three-lobed cam. This slot is eccentric with respect to the axis of the part. A half-round spring will go into the slot in assembly and in service works between the high points of the cam lobes to lock the synchronizer ring into the second and third speed clutch. The cam turning operation is performed on a Porter-Cable, and the piece must be set in correct angular relationship to the synchronizing slots.

All turning operations up to this point are given 100 per cent inspection. The inspection fixture has three dial indicators which are applied to check the run out of the face and

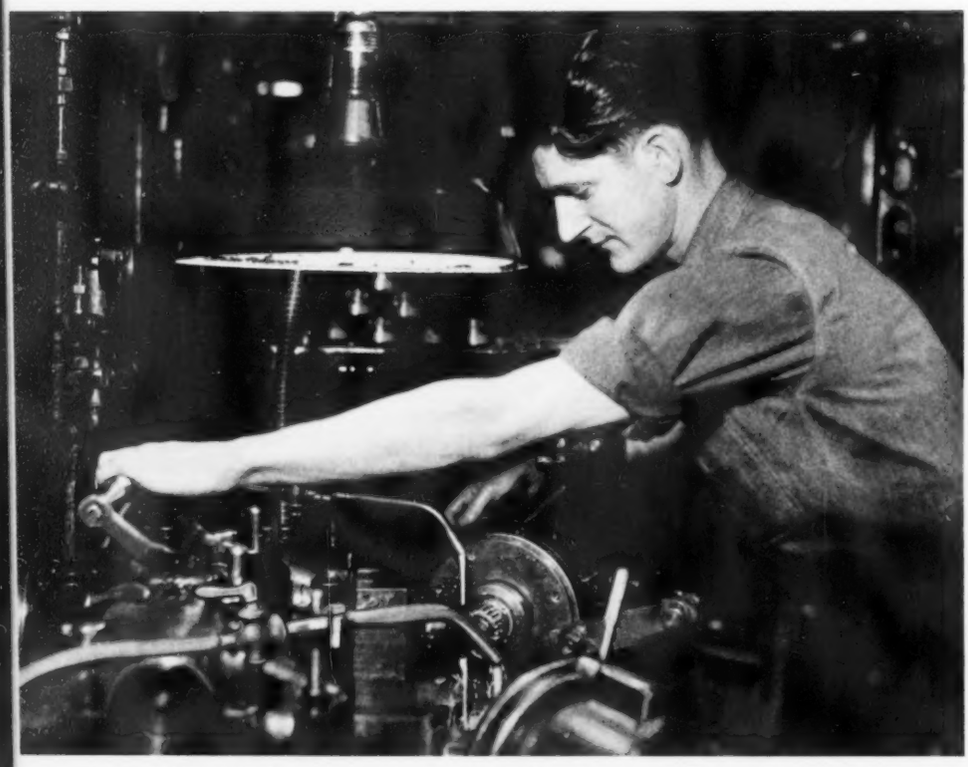


For the clutch gear, which presents the same problem as the second speed gear with respect to cutting synchronizer slots from gaps in the clutch teeth to the relief slots, a Fellows is now set up with two cutters in alignment. Clutch teeth and synchronizer slots are cut simultaneously, thereby saving a second handling

O.D. and the location of the cam lobes. Ten pieces from each hour's production are inspected with thirteen other gages.

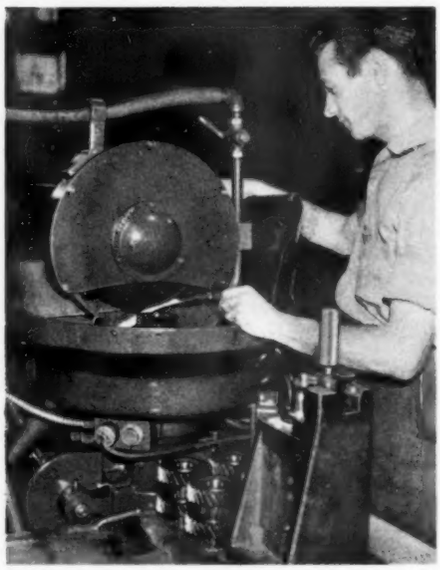
A battery of fifteen Fellows gear shapers cut the clutch teeth, three gaps being left as shown on the part drawing. The gear is held from the hole in the face to assure concentricity. Two operators handle these machines. Cutting the three synchronizing slots, which run from the gaps in the clutch teeth to the face of the gear, is done on a special Cross machine. The operator places the part on a mandrel and loosely inserts it into the work head, clutch teeth out. A swinging bar with a tip that fits between a gap in the clutch teeth is swung forward to locate the gear correctly, and the work is clamped by air. While the work head reciprocates the gear, the three radially disposed tools feed to depth under electric-hydraulic control.

Chamfering the front edges of the slots is a very fussy operation and is done on another Cross machine. The gear is located from the large end and is held by a U-washer and pull bar from the air cylinder. Periodic inspection of the height of the chamfer or "apex" with relation to



Fifteen clutch teeth on the second speed gear are rounded on this two-spindle Lipe machine to permit easy engagement. The spindles are indexed automatically by geneva movements, and the chucks are operated by air

Back face (large end) of the gear is ground on an Arter surface grinder, and the apex of the chamfer in the synchronizing slots to the back face is checked on an inspection fixture



the back face of the gear is done right at the machine with a box-type fixture. A conical point is dropped into the apex, and the dial indicator shows if the dimension is off. The drawing calls for a limit of 0.005 in., but the gear department endeavors to hold this dimension to 0.003 in. The reason for this is that when the gear is hardened and both faces are ground, the cam slot will then be within the drawing limits and the over-all length will be right.

So that the clutch teeth will work properly with the internal splines of the second and third speed clutch, the tooth ends are rounded on a duplex Lipe gear-tooth chamfering machine. The work spindles are indexed by geneva movements and the chucks are operated by air. Operation is automatic once the cycle is started. This is the last operation on the clutch end of the second speed gear.

A battery of four Cleveland eight-spindle automatic hobbing machines is employed to semi-finish hob the 26 helical teeth on the large end. This operation must leave only 0.001 in. per side of tooth or "wall" for shaving. Size and concentricity are checked on a special fixture in which the gear is rolled with a master. Since the hobbing operation leaves one razor-sharp edge at each end of the tooth, the gear must be chamfered on a special Cross machine to prevent "hicking" — breaking or burring of the sharp edge. Thus, the gear is protected in service, even though it runs in constant mesh.

Shaving is done on Michigan rack-type gear shavers which give 50,000-60,000 pieces per grind of the rack-type cutter. These tools have already had eight or nine grinds and many more are possible.

Final operations on the green gear include drilling three oil holes in a special General Motors Research horizontal drill with cam-driven heads; reaming the hole with a hand fixture to remove burrs, and inspection. The finish bench and floor check consists of:

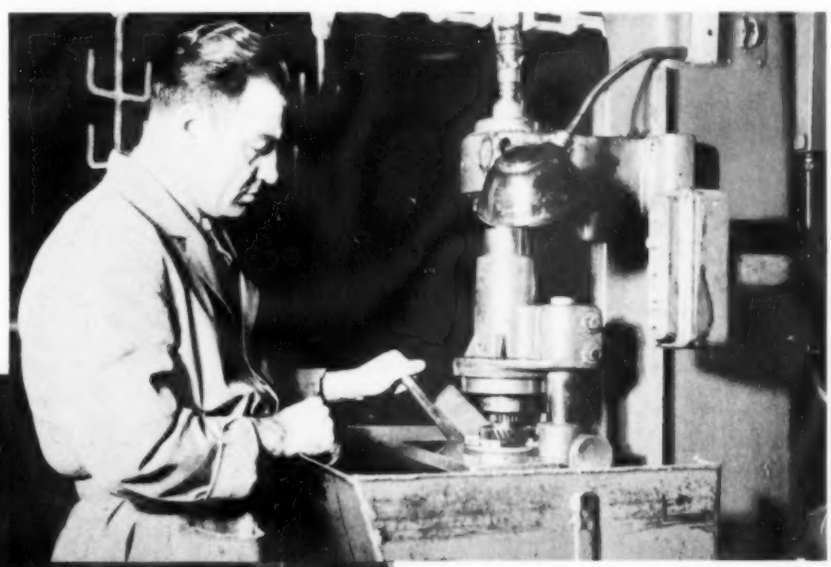
A. Visual inspection of all gears, consisting of inspection for peel and burrs on clutch teeth, apex chamfer for being on center and finished, chamfer on clutch teeth for being on center and finished, oil holes and their location, chamfer on ends of 26 teeth, and general finish of the racked teeth.

B. Visual inspection as in Item A, but with particular attention to the chamfer on the clutch teeth for depth both ways. Six gages are used on about five pieces, once to three times an hour.

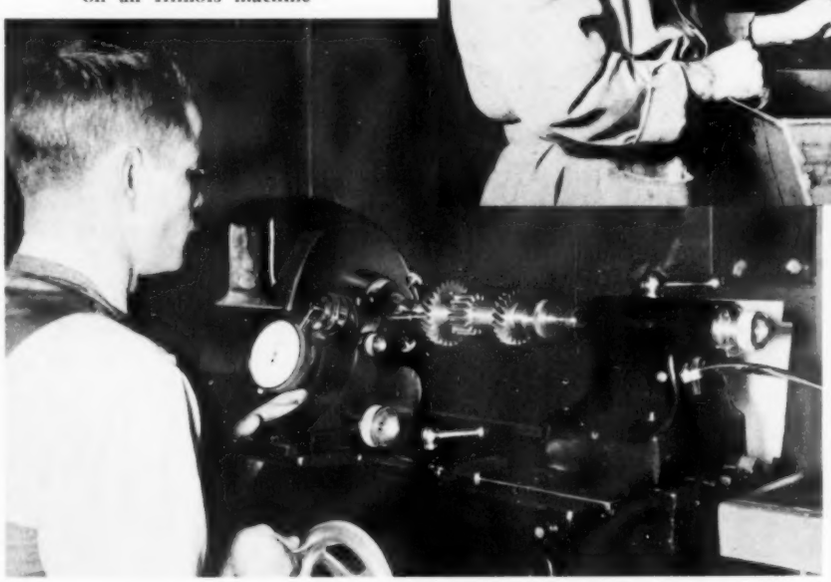
A large glass-inclosed inspection room in the machining section is completely equipped, and it is divided in half so that continuous inspection for tooth spacing, profile, run out and pitch diameter can be done in one half and testing for noise and bearing of gears can be done in the other half. In the second room the gears are run in sets on gear speeders. Most of the gear inspection equipment in use is of Illinois Tool design and represents every type of machine that can be profitably used in inspection of gears.

Passenger-car gears passed by inspection are hung on alloy steel racks suspended from the service conveyor and are transported to the heat-treating department. Here they are cyanided at 1,490 F., quenched in oil and drawn at 480 F. for 90 min. Final hardness of the gear is Rockwell C 49-54. The conveyor racks carry the gears back to the grinding department.

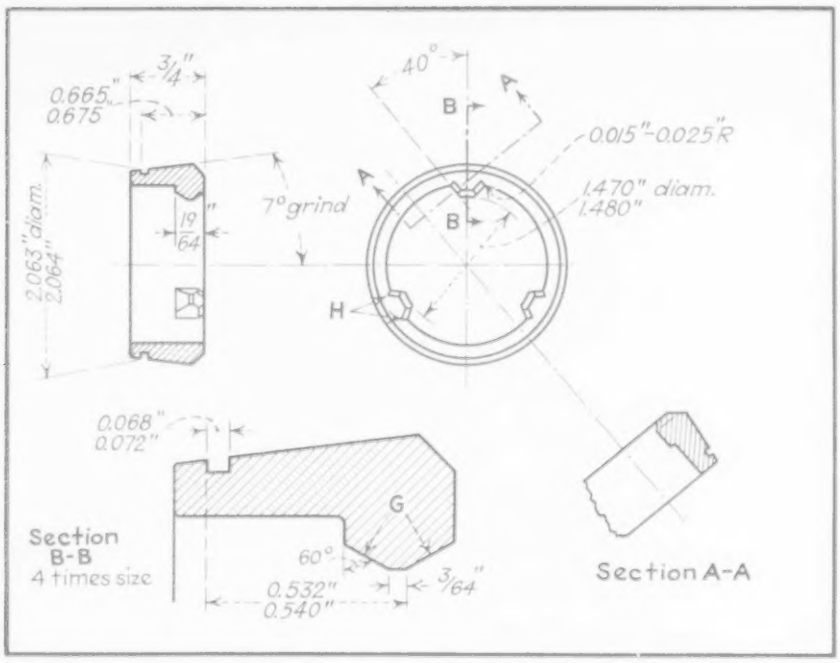
The first finishing operation after the gears are picked off the conveyor is to hard burnish on a G.M. machine to break any little scale and to give



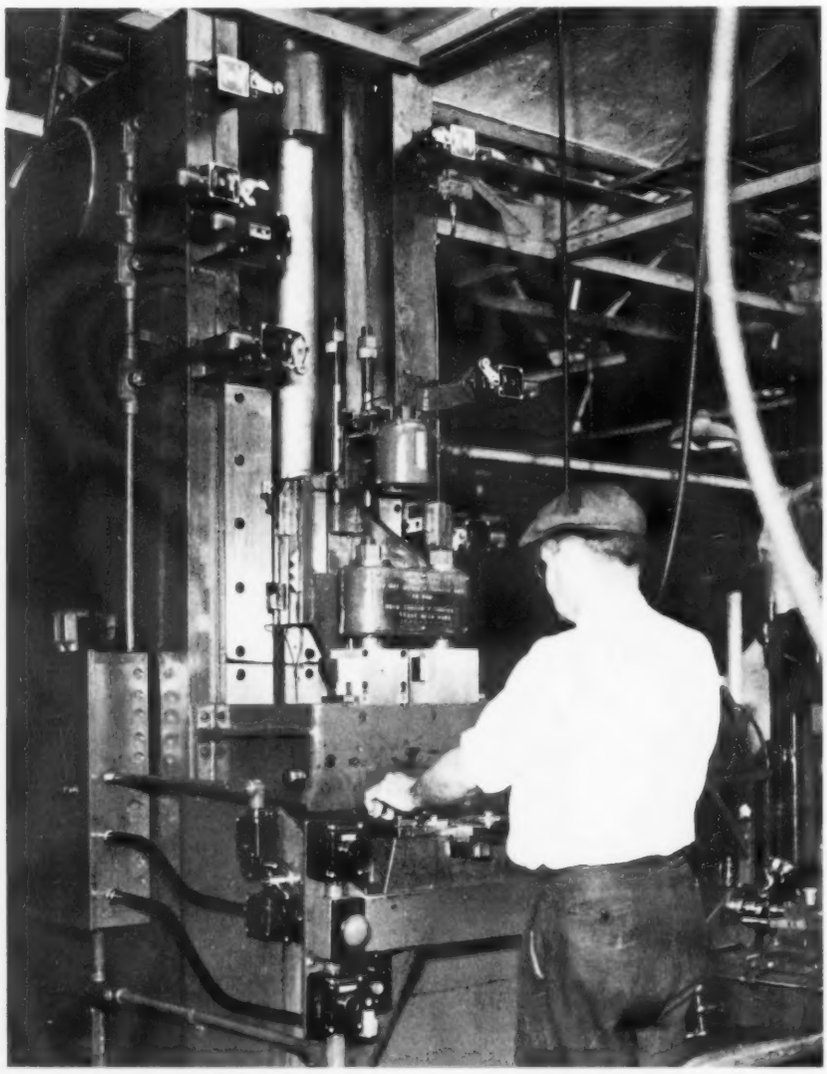
The gear is not held rigidly while honing the bore on a Barnes single-spindle because a rigid set-up would cause stone breakage if the bore and back face were not absolutely square



Continuous inspection of tooth spacing, profile, run out and pitch diameter are carried out in a well-equipped glass-inclosed inspection room. Here the operator is checking lead of a helical gear on an Illinois machine



Chamfers *G* in this synchronizer ring were formerly machined in a drill press, but an automatic was installed to combine this operation with others



The chamfered internal flange on the synchronizer ring, as left by the Conomatic, is broached out on a two-spindle American to leave the three synchronizer lugs that mesh with synchronizing slots in the clutch gear or second speed gear

Another fussy job is chamfering the corners of the synchronizing lugs on a special Cross machine

After cyaniding, the synchronizing ring is rough and finish ground on a single Norton cylindrical grinder. The table is set over to the proper taper, and roughing is done on one half of the wheel face and finishing on the other half

the grinding operator clean teeth to work with. The gears are then passed back to a Heald Sizematic and a Gagematic for grinding the hole. The gear is inserted in a cage having three sets of double pins to fit in the helical teeth at the big end and the whole cage is inserted in a three-jaw draw-in chuck. Next an Arter surface grinder grinds the back face of the gear to a definite height with relation to the "apex" in the synchronizing slots. The operator does one piece at a time. Face grinding the small end, however, is done on another Arter with a dial fixture that holds eight gears. Both faces of the gear are then polished on a floorstand grinder, using a felt wheel and wax. The faces are polished to a highly reflecting surface to give a good bearing for the thrust loads imposed upon them. Another hand operation consists of polishing the chamfers on both ends of the hole, using a piece of emery cloth held in a slot in the end of a tapered spindle. The final machine operation is honing on a Barnes single-spindle. The fixture is not rigidly fastened down because if the face of the big end of the gear and the hole are not exactly square, the hone, which tightly fits in the hole, would bind and break.

When the finish ground gears are taken from the conveyor at the final inspection department they are demagnetized, and the following routine pertains:

A. About twice an hour the bench center is used to check five pieces for hub run out, and five other pieces for face run out.

B. All gears are checked with gages for the width of the cam slot, and rolled for pitch diameter run out, and

hicks. Visual inspection includes a check for all operations being completed, clean up on all ground surfaces, chamfer on clutch teeth, burrs, alignment of clutch slots with synchronizer slots, dirt and color.

C. About twice an hour an inspection includes: over-all length; size, run-out and lift of cam lobes; hub to cam slot; size of apex chamfer; run-out of synchronizer slots from hole, and taper in the ground hole. If error is found the group leader is notified and the incorrect dimensions are checked 100 per cent, and the pieces that do not pass are set aside.

SYNCHRONIZER RINGS

SYNCHRONIZER RINGS are machined from G.M.C. 1050 A bar steel on 2⅝-in. Conomatic eight-spindle bar-feed automatics. These machines drill, form, ream, chamfer and cut off the tapered cone-like ring at the rate of one piece per 25 sec. Parts purchased outside had a straight-sided internal flange and had to be chamfered both sides as at *G* in the drawing. The Conomatics were installed for the sole purpose of eliminating chamfering on drill presses, and to get a finished turned piece off the machines with burnished angles on both sides of the flange.

The tapered flange as left by the Conomatics is broached away on a two-broach upright American machine to leave the three synchronizing lugs. These cam lugs will enter the synchronizing slots in the second speed gear. Controls are fitted to the broaching machine to prevent its being reversed and breaking the tools.

After washing comes one of the most important operations. It consists of milling the chamfer in the two outer edges *H* on a special Cross machine. Indexing is ticklish on this job and for accuracy it was necessary to resort to engaging a heavy locking pin successively in three hardened bushings in the chuck. Burring the large face completes the operation on the green part.

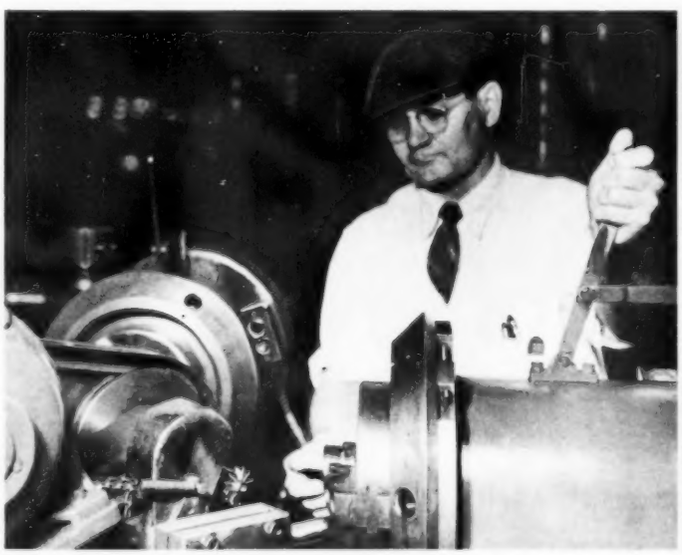
Ten gages and a definite routine have been developed for checking the rings in the green. The ten inspection operations consist of:

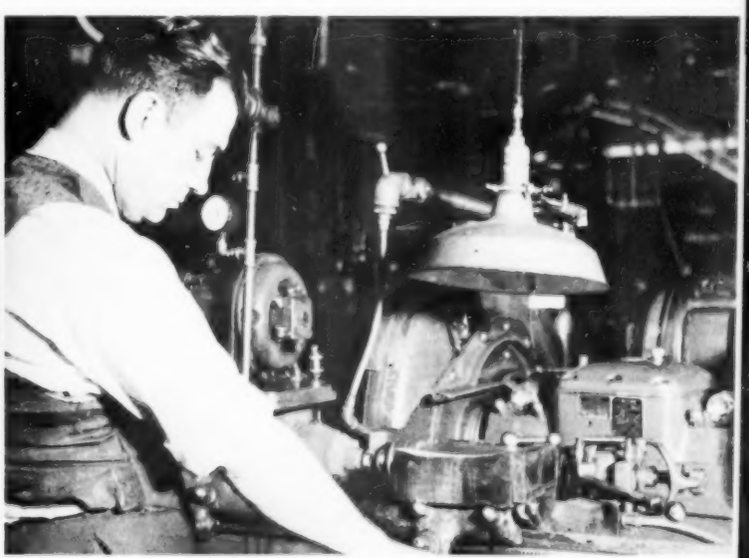
1. Inside diameter of lands with plug gage
2. Large broached hole
3. Location of side of lug — dimension 0.4135-0.4185
4. Width of slot — 0.072-0.068 in. dimension
5. Inside diameter of groove
6. Chamfer and 0.610-0.600 in. dimension
7. Ring for cone angle
8. Outside chamfer angle and size
9. Ring groove to back face
10. Ring groove to leading land edge

The definite inspection routine assures little difficulty in assembly. The inspector spends about half his time at the bench, and checks visually the hour's production. Visual inspection comprises size and angle of outside chamfer, width of lands, burrs and completeness of all the operations.

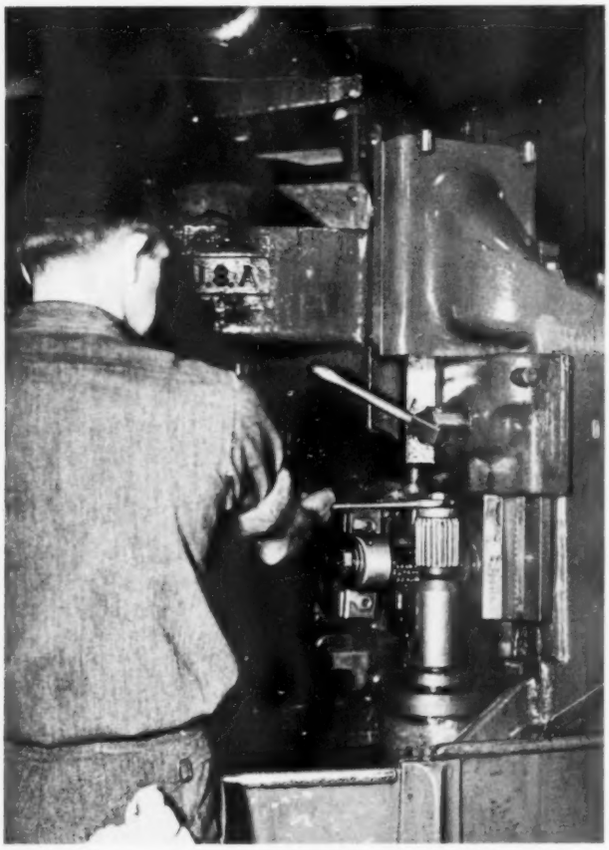
All pieces are held on the inspection bench until a random selection of ten pieces is checked with gages for the first eight inspection operations. Should error be found, the inspector notifies the foreman or group leader, the inspection group leader, and checks 100 per cent on the wrong dimension until corrected. The group of parts previously passed is checked again for the error found in the inspection of the current lot. Moreover inspections 9 and 10 are used in the department once per hour.

Inspected rings pass to cyaniding at 1,490 F., quenching in oil, and drawing at 350 F. to Rockwell C 48-53. After rinsing, the rings are returned to the machine shop for grinding. Rough and finish grinding are done on a single Norton with the table swiveled to the cone angle. One half of the wheel is used for rough grinding, and the other half of the wheel for finish grinding. Corners of the three lugs are polished, the rings washed and then sent to inspection. The 7-deg. angle and the 2.063 in. dimensions are checked with a ring gage so that the front edge of the groove in the part just matches one face of the gage. Taper and diameter are important, because if over- or undersize, the groove in the ring will not match up with the slot in the second and third speed clutch during assembly. Width and depth of the groove are checked with a snap gage. Truth of the bearing afforded by the tapered surface is checked by bluing and wringing in a ring gage. This bearing is important because the part mates with a tapered bronze bushing in the end of the second and third speed clutch.





Following precision boring, the sleeves are given three inspections: run-out of bore with dial indicator fixture; snap gaging of diameter; and for depth of boring of pilot end

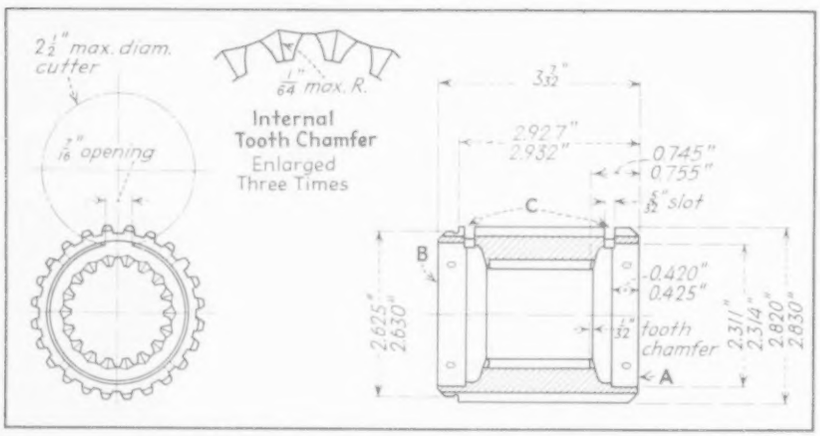


Class *A* hobs are used to cut the external spline on the second and third speed clutch. This operation is done on a battery of four Cleveland eight-spindle automatic hobbers

2nd AND 3rd SPEED CLUTCH

THE SECOND and third speed clutch, which slides freely on the mainshaft splines, has eighteen internal teeth that mesh with the teeth of the clutch gear or second speed gear after synchronization. The 24 external teeth serve only as splines for the first speed gear. Both ends of the clutch are also fitted with bronze cones that ride on the synchronizer rings. In addition, a steel ring is welded at one end, to afford means of moving the sleeve when shifting.

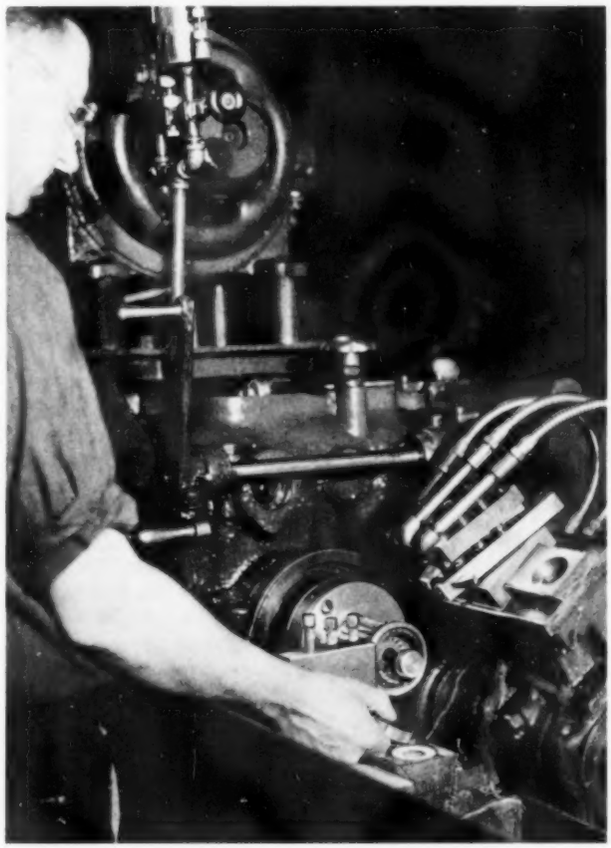
The clutch is forged from 2-in. bar stock on an Ajax upsetter in a manner similar to that for the second speed gear. In the machine shop, the first operation consists of core drilling on a four-spindle Baker gang drill. Rough broaching follows on one twin American machine after which the operator passes the piece to a second twin American for finish broaching. The operator of this machine passes the broached part behind him to a trough which serves three Bullard Mult-Au-Matics. Two trips around the Bullards complete rough counter boring and facing of both ends. In the first trip around one end is counterbored and faced, and when the piece comes back to the unloading station the operator reverses the part on the splined arbor for the second trip through the machine. Finish counterboring on the end *A* opposite the pilot end *B* is done on an upright Natco.



Depending upon the position into which the second and third speed clutch is shifted, the internal involute splines mesh with the clutch gear or the second speed gear

The part now progresses to a Fay automatic which holds the piece on a splined arbor while the O.D. is turned, and the 2.625 in. diameter on the pilot end is turned and chamfered. The piece now goes back to a Baker drill to finish counterbore the pilot.

Both ends are next precision counterbored to 2.311 in. in diameter on a double end, two spindle Ex-Cell-O,



Straddle facing the ring on a Fay automatic must be held to close limits with respect to the opposite end of the part

Staking the bronze cones into cross drilled holes in the counterbores is done by four horizontal tools that move radially

using Carboloy tools. These counterbores are 0.420 in. deep and receive the bronze bushings or cones.

Inspection follows immediately to determine the height from the end opposite the pilot to the depth of the counterbore in the pilot end. The pilot end is also snap gaged, and run out of its counterbore with respect to the splined hole is determined with a dial indicator. Machining operations are resumed by chamfering both ends of the internal splines on two double-spindle Lipe gear chamfering machines. A hand fixture is used to burr broach the piece after this operation.

A battery of four Cleveland eight-spindle automatic hobbing machines is used to hob 24 external teeth from the pilot end. This is a one-cut job and must be done with Class *A* hobs. Inspection is done with pins that locate very close to the pitch line and the overall dimension over the pins is measured with a micrometer.

Two slots *C* are milled on a Cincinnati with two fixtures; one being used for loading while the other is in the cut. Punch presses are set up with die sets and tools to remove the burrs from the slots, and the piece is ready for assembling a ring or flange on the pilot end. This ring is applied so that the shifter mechanism can slide the clutch either way on the mainshaft.

The operator stakes the ring to the pilot end of the clutch and puts it into a special welder. This machine has a G.E. automatic welding head assembled with necessary controls built by Chevrolet. The part is held in a rotating chuck which is timed to start after the head comes down and begins to arc weld around the joint between the flange and the pilot. The part, as it comes from the welder, has a high spot where the cycle was started and so the rough spots are reduced on a snagging grinder for the straddle face operation.

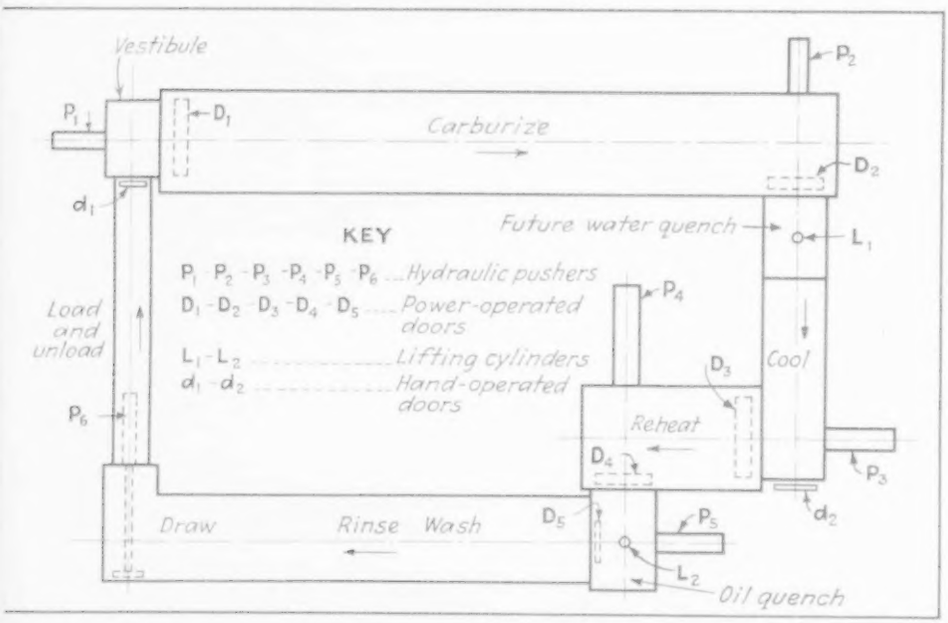
The last important machining operation before hardening is to straddle face the ring on a Fay automatic. This operation must be held very close because of its importance in shifting. The piece is immediately inspected for relation and run out of the inner face of the ring with respect to the face *A*.

After hardening, the clutch is internally ground on the tops of the splines by using a Heald Gagematic. A spring-type collet chuck and a cage hold the piece. Next the outside face of the flange is ground on a Norton by putting the piece on a cam-type arbor that locks against the round part of the hole.

Bronze cones are pressed into both counterbores and are rough taper bored on a Heald double-end two spindle boring machine. Since some means must be used to hold the rings securely, they are staked into four holes previously drilled through each counterbore. Staking is done in a Fox hydraulic press fitted with four horizontal tools actuated by cam bars. The last machine operation is to finish bore the rings on a Heald single end machine, the part being held on an expansion arbor. The finish boring is not smooth, but is equivalent to a fine thread so that in service the cones will quickly wear in with the hardened synchronizer rings and provide a 100 per cent bearing. Since the cones also have cross slots to scrape oil from the rings when the parts come into engagement, these slots must be burred after the boring process. This is done on a hand fixture with appropriate splines. The finished second and third speed clutch then goes to final inspection.

AUTOMATIC CARBURIZING

THE CHEVROLET Muncie plant now has in operation in its heat-treating department one of the most unusual carburizing furnaces in the country. The set-up is an automatic heat-treating machine in which the work to be carburized is loaded into the entering end of the furnace by an operator, traverses a roughly U-shaped path in going through the cycle, and comes back to him for removal at the same station. Each 30-minute cycle delivers 557 lb. of work, but the production can be varied between 1,100 and 1,600 lb. per hr. by varying the length of time during which the work is in the equipment. Natural gas is employed; about 2,500 cu.ft. per hr. is used for carburizing atmosphere plus 1,500 cu.ft. per hr. for fuel. A case depth of 0.040 in. is secured.



Diagrammatic sketch of the automatic installation for carburizing 1,100-1600 lb. of truck gears per hour, using about 4 cu.ft. of natural gas per pound of material

There are many engineering features in this set-up, but one of the most important is the fundamental idea for the carburizing chamber itself. If, the engineers argued, it would be possible to do away with an alloy muffle by using a brick chamber instead, the expense of the muffle replacement would be avoided and the carburizing chamber could be made to any desired cross section. Moreover, they believed that the brick muffle could be utilized as the cracking chamber.

Before the brick muffle could be embarked upon, it was necessary to discover whether a brick could be obtained that would stand up in a carburizing gas atmosphere. Tests revealed that brick free of iron oxides would be satisfactory. The iron oxides cause cracks, spalling and disintegration of the brick in a couple of hours under carburizing service, whereas brick free of iron oxides can be passed as satisfactory if it stands up for 10 hr. Experiments showed that a case of 0.032 in. were obtained with new brick, but later when the brick had completed absorption of carbon, a case of 0.060 in. could be obtained in the same time and with the same temperature. Since a case depth of 0.040 in. is sufficient, the brick muffle was sustained.

Maintenance expense on this furnace is expected to prove much lower than in more common furnace designs. First, replacement of brick may not be required more than once a year. This can be done conveniently during the yearly model change. Second, brick is much cheaper to replace than alloy muffles. Third, the heating tubes can be taken out and replaced in a day's time, and without shutting down the furnace or interfering with its proper operation. Fourth, maintenance of nozzles is eliminated.

Economies of the new process are obvious when it is compared with the old method. The latter required: (1) work packed in containers, (2) containers pushed into a car-type carburizing furnace, (3) work dumped, (4) work hung on loop conveyor to cool, (5) work put in fixtures and pushed through reheat, (6) quenched, (7) washed, (8) loaded into baskets and drawn, (9) sandblasted.

As shown by the drawing, the operator stands between the entering and leaving sides of the U-shaped heat-treating machine. He removes green gears from the conveyor and loads them into trays. Delivery of a finished tray at 30 min. intervals starts a new cycle throughout the machine. The operator pushes a button to operate a power-operated door on the entering side and pushes a tray inside. When he closes the door, the hydraulic pushers P_1, P_2, P_3, P_4, P_5 and P_6 operate in timed sequence to advance the work in the system by one tray at a time.

The new tray will eventually pass through the carburizing furnace at 1,750 F., and be pushed at right angles through the cooling section. Provision is made in the cooling section for a water quench, but this will not be used with the present analysis of material. At present the gears go through the cooling section only, where the water jacketed walls reduce the work temperature to 750 F.

Quenching Mechanism

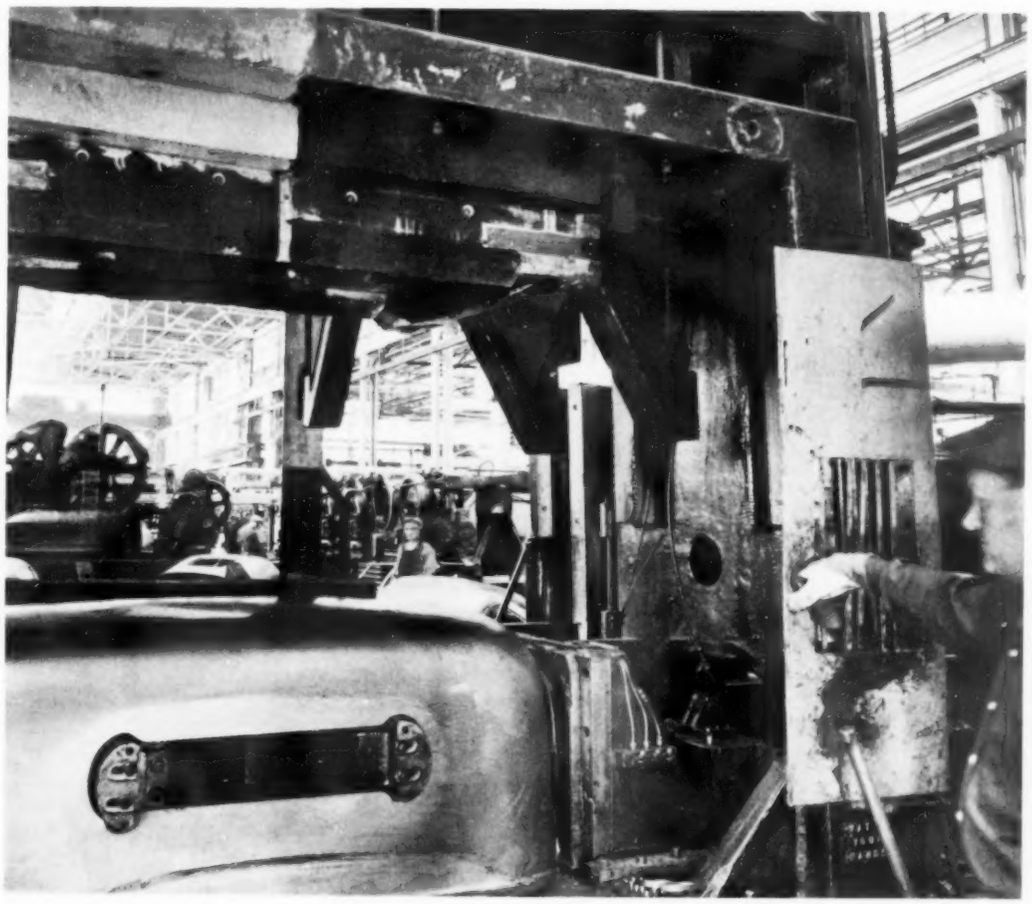
After being cooled, pusher P_3 changes the direction of the work and passes it into the reheat at 1,490 F. Pusher P_4 transfers the work from the reheat to the oil quench, a lifting cylinder dropping the tray down and bringing it up again. In timed sequence pusher P_5 then causes the tray to advance through the washing and rinsing station where the work temperature raises to 180 F. Drawing raises the temperature to 350 F., and pusher P_6 discharges the tray at the unloading station.

The carburizing furnace, as mentioned previously, is heated by radiant alloy tubes that are easily replaceable. The tubes are L-shaped, the long leg running from a point on one side of the furnace (where firing is done) across to the other side where the short leg drops down to a sand seal. Products of combustion from all tubes go into a common tunnel under the furnace floor. Some of the products of combustion are fed back into the drawing furnace. This automatic carburizing installation was built by Continental Industrial Engineers, Inc.

PRESSED METAL

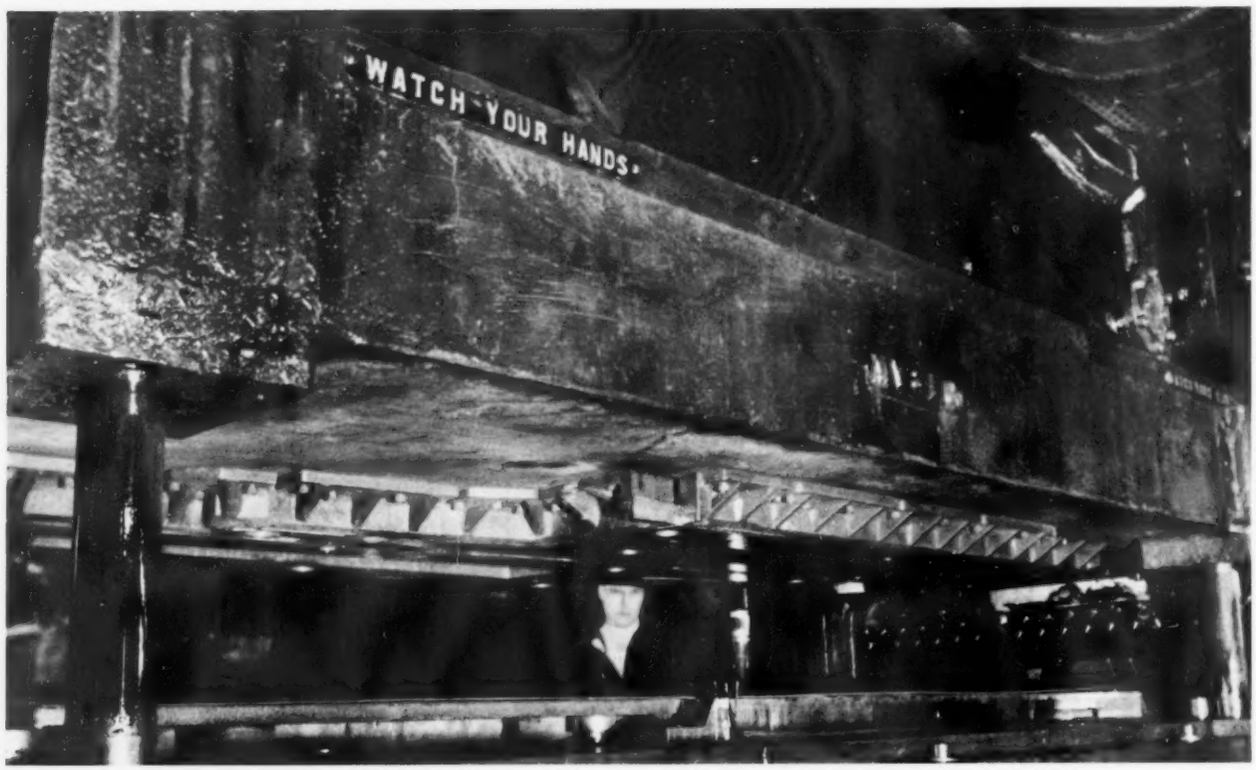
TRUCK CABS

NEARLY nine hundred sheet metal parts are used in the Chevrolet engine and chassis apart from those used in the body. Fenders, running boards, hoods, grilles and gas tanks are a few of the major parts made at Flint in Plants Nos. 6, 8 and 10 of the Pressed Metal Division. Other parts too numerous to name bring the total production of these plants to a volume that requires approximately 1,000 tons of sheet and strip metal a day. Since nearly a third of the metal used becomes scrap the problem of baling and disposing of scrap must be given equal consideration with arrangements for efficient handling of finished parts. Each of the three plants has its own die room equipped for making and maintaining the dies used on its products.



Truck cab panels are formed in a 400-ton Clearing press. This work is done in Plant No. 10, newest and largest unit of the Pressed Metal Division at Flint

A large three-way die sets in the door opening and windshield flanges. This work is done after windshield sides are welded on. A 48-in. stroke 250-ton Bliss mechanical press is used



Rear fenders are blanked two at a time from wide strip stock in a 120-in., 500-ton Bliss press. The sheet steel is automatically fed from a coil supported on hardwood rolls and power driven to prevent any pull on the feed mechanism. The two fenders are nested to fit together so there is no scrap between them

REAR FENDERS

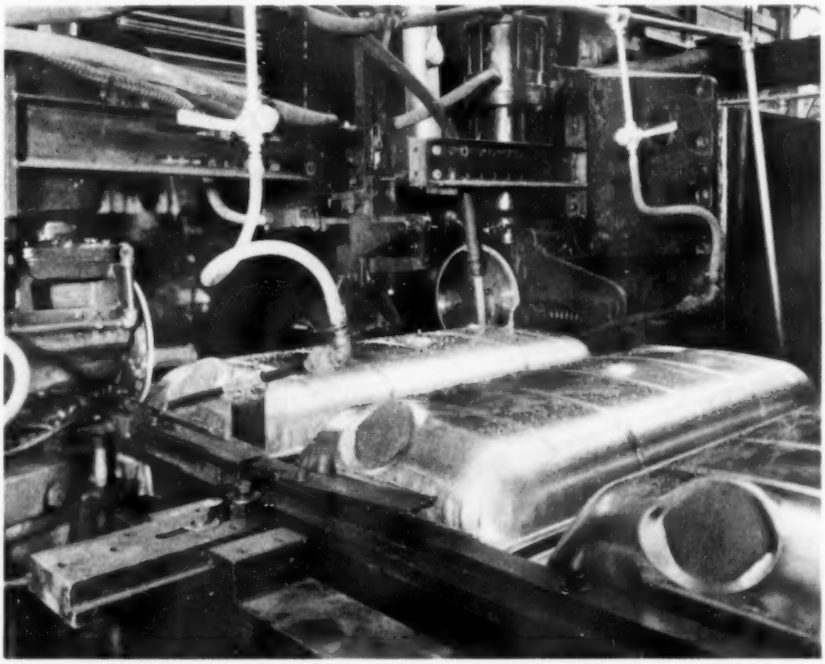
TOE & FLOOR BOARD

Sound and heat insulating material is put on the toe-and-floor board plate four at a time in a 50-ton hydraulic press. The metal part has already been formed and the insulating material blanked to size. The dies are electrically heated at 200 F. which softens the binder so no other adhesive need be used. Cool air is supplied at the sides of the press and exhausted from above to keep working conditions comfortable.

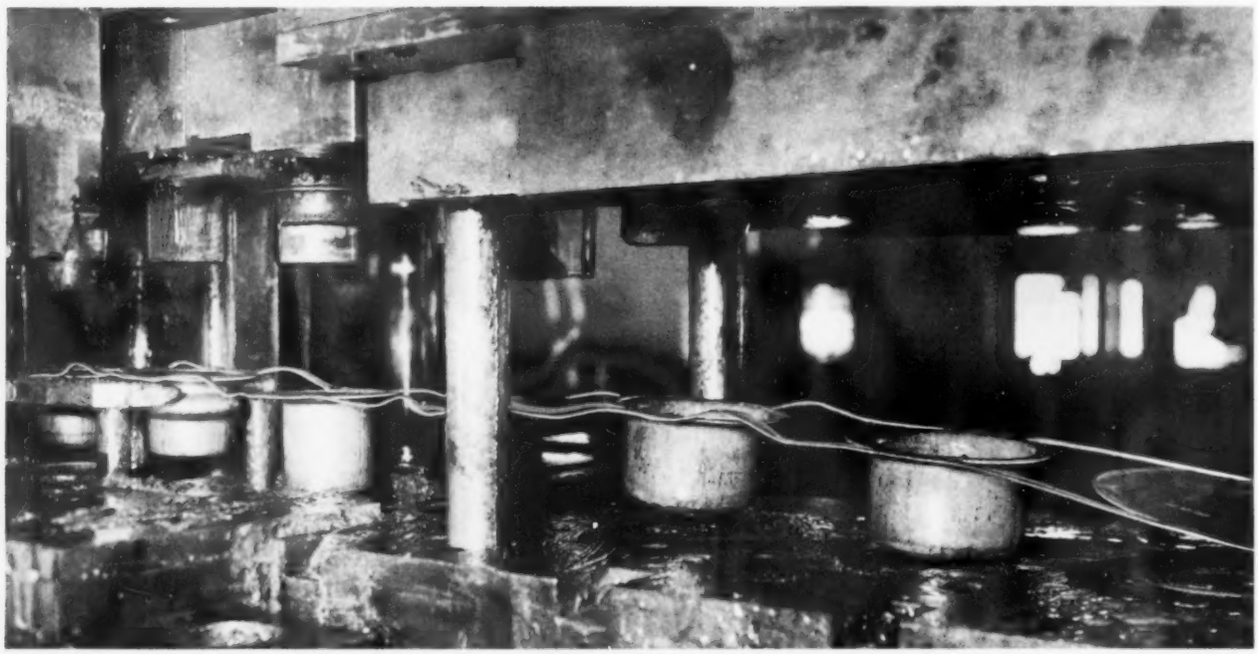
The gasoline tank is blanked and formed in halves in a double-acting 150-ton Cleveland press. This work is done in Plant No. 8

GAS TANK

After the tank halves are pierced and trimmed and inside fittings soldered in place, they are tack welded together in a National welding machine

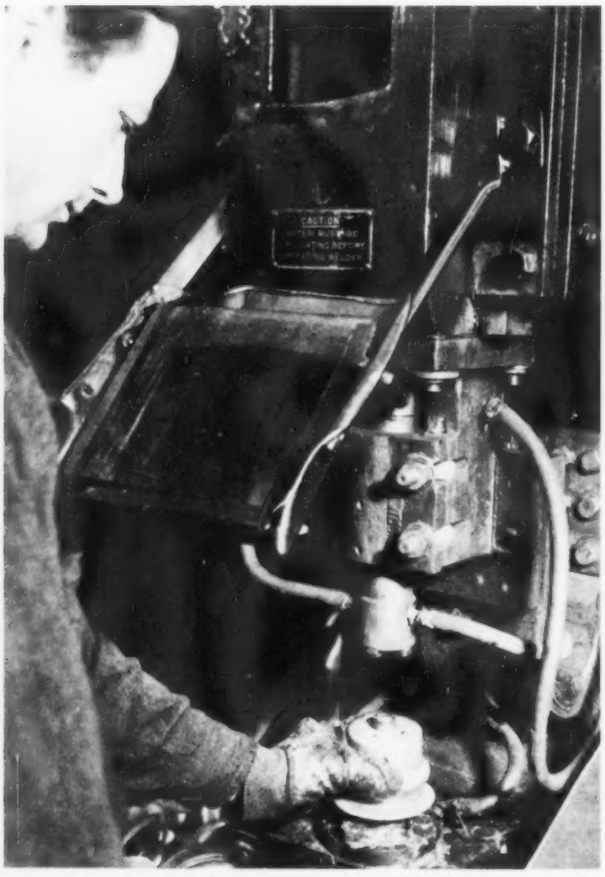


Finish welding on the gasoline tanks is done by seam welding. First the tanks are carried endwise along a conveyor while the sides pass through the rollers. Then they go through another welder sidewise to seal the ends

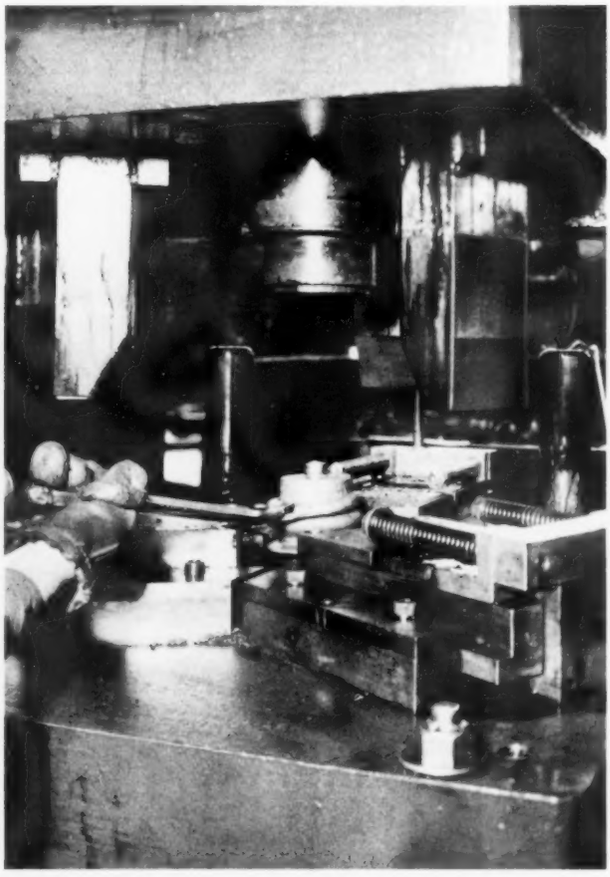


Sixteen-gage strip steel is supplied from a coil for the first operation on the water-pump and fan pulley. The work is done by an eight-stage progressive die in a 250-ton Bliss press

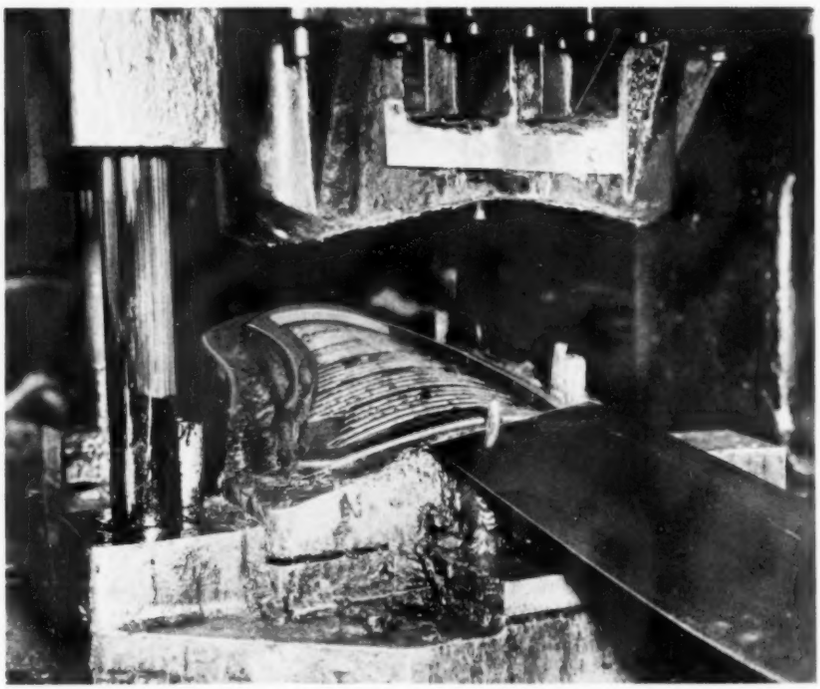
WATER-PUMP AND FAN PULLEY



A steel hub is welded to the inside of the pulley stamping by the projection process in a 200-kva. National welding machine

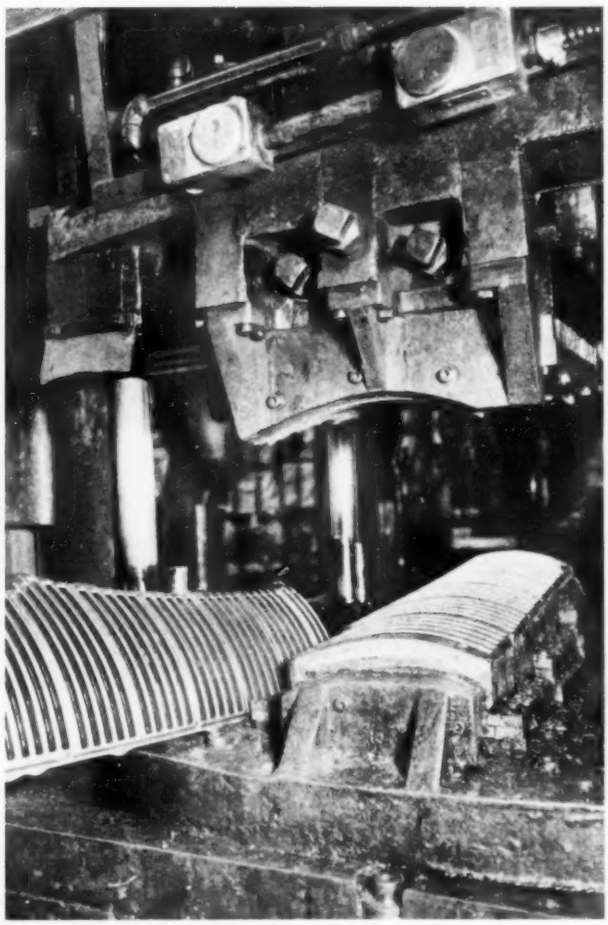


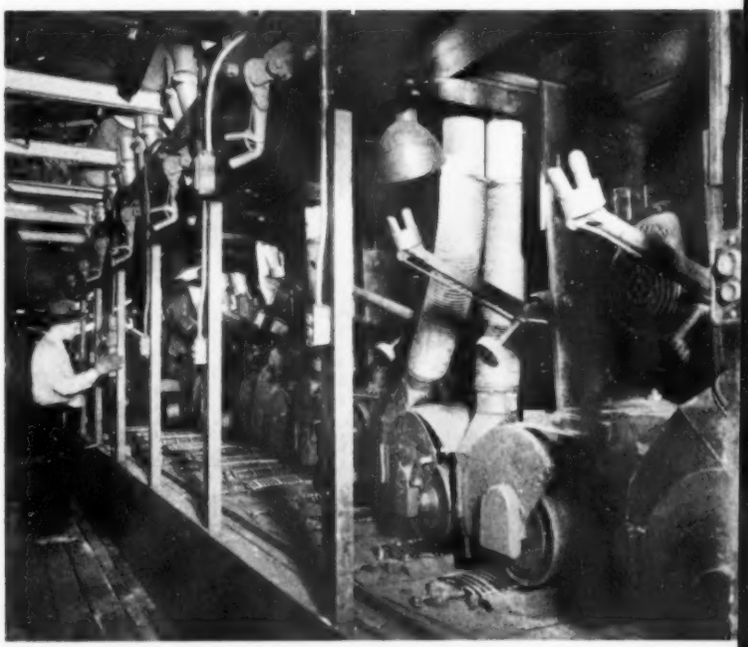
A three-way die forms the second flange on the sheave. The piece is pushed downward while the sides are bulged into the die



The first operation in the radiator grille is to emboss the blank in a 650-ton Marquette press with a cushion bed

RADIATOR GRILLE

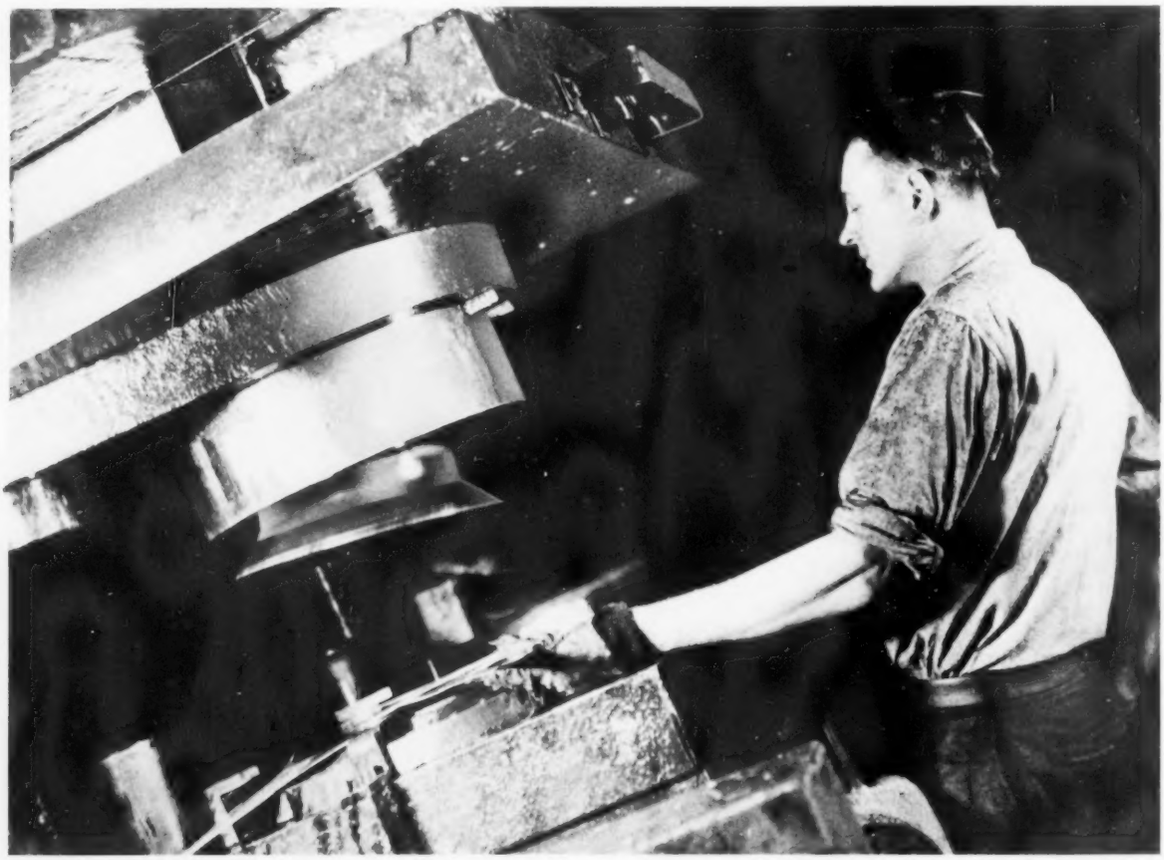




Grilles are buffed automatically by a series of wheels while being carried along on a chain conveyor. They are then washed and plated with copper, nickel and chromium

After the ribs are gashed and lanced, the piece undergoes a flanging operation which turns down the ribs and outside flanges. A 250-ton Bliss handles this step

WHEELS



Disks for Chrevrolet sheet-metal passenger car and truck wheels, while of somewhat different shape, are blanked, drawn, pierced and formed in parallel lines of inclined presses. Here a drawn disk for a 16x4.00-in. passenger car wheel is seen dropping from the die into a chute which will deliver it to the next press in line

ASSEMBLED IN RADIAL DIES

WHEELS on which Chevrolet passenger cars and trucks roll are fabricated to the exacting standards found throughout the company's other manufacturing lines. Located in the Detroit Gear and Axle Division's plant, the wheel lines are so arranged that high production efficiency can be realized even when manufacturing quantities are below the maximum capacity obtainable. Here, as in all other Chevrolet plants, tools and equipment are selected for their adaptability to the operation to be performed, raw material is checked against purchasing specifications before release for fabrication, and inspection department control stations located in the production lines insure continuous manufacture of parts according to pre-determined standards.

Sheet stock, rough blanked at the mill to reduce scrap to a minimum, is delivered to the disk and rim blanking presses direct from the box cars in which it is received. Disks for 16x 4.00-in. passenger car wheels are blanked and drawn in No. 79¾ Toledo presses, two men being required to feed the sheets to each of these first operation presses. Disk blanks are ejected into chutes leading to the second operation press where the center hole is pierced and the first forming operation is performed.

Succeeding operations, each performed in a press located in line and supplied with disk blanks by chute from the preceding press, include: (1) curl and drift center hole, (2) finish form and drift, and (3) pierce and countersink for clip rivets in a No. 58½ Toledo press. Next, the disks are delivered to a work bench, located in the press line, where six hub cap clips with one rivet each are placed by hand around the disk and the rivets are headed in a No. 78 Toledo press. Clips are sized in a No. 4A Bliss press following the riveting operation. At this point the disk and rim lines converge for assembly.

Rims for passenger car wheels are formed from flat plate stock which is received from the mill in rough sheared sections of approximately the correct size. These flat blanks are trimmed in No. 203B Toledo presses and looped in special rolling stands. Here, again, there are two manufacturing lines paralleling each other. Located close beside each rolling ma-

Rims are rolled from flat plate stock, then butt welded in one of two 500-kva. heavy-duty machines. Close by are flash trimming units to which the rolled shells are passed directly from the welding machines. From here the shells go to forming presses and then to a rolling machine before assembly with the center disks

Segmental expanding dies in two Cleveland heavy-duty presses form wheel rims from the straight shells delivered by overhead conveyor to the press group. Following an intermediate rolling operation, rims are sized in a heavy press also equipped with a top and bottom segmental die. Following a taping operation and a careful inspection, wheel rims are returned to the press group for assembly with center disks, punching in a heavy-duty press and then riveting in a second press. Under normal conditions 800 passenger car wheels are delivered to the shipping dock each hour

chine is a butt welder of 500 kva. capacity where the rim ends are closed and welded. Flash is trimmed in a Morton trimmer or a No. 14 Toledo press, then the tubes are hung on a chain conveyor which carries them to the forming presses.

The first forming operation on passenger car wheel rims is performed in a No. 20S Cleveland press and the second in a No. 90D63 Cleveland press, each press being equipped with a segmental die that works in a horizontal direction radially around the rim blank. Following the first and second forming operations the rims are finally shaped in Jaxon rolling machines, then expanded to size in presses using segmental dies.

Sized rims drop into a chute which delivers them to a table adjacent to a conveyor line. This table is pneumatically operated and loads the rims on conveyor hangers automatically. These rims are delivered to a work bench, being unloaded automatically from the conveyor, where the circumference of the rim is taped. Here, also, the rims are checked for size before they are hung on the conveyor for delivery to the press line.

Disks and rims are assembled by hand at a work bench and slid along this bench to a No. 79¾ Toledo press where sixteen rivet holes are pierced and countersunk in a radially-operated segmented die. Pierced assemblies then are delivered by chute to a second work bench where two men position sixteen rivets, using an air-operated fixture. Wheel units are then delivered to another press where all sixteen rivets are headed in one operation.

Next, the valve stem hole is pierced in a No. 14 Toledo press and chamfered in a second press close by. Finished wheels are delivered by conveyor to an inspection group where each wheel is carefully checked and, if approved, placed in a chute from which it automatically is lifted by an overhead conveyor for delivery to the shipping dock.

Truck wheels, while of somewhat different design, also are formed from flat stock and pass from operation to operation in controlled sequence. Careful attention has been paid to tool and fixture design throughout both the passenger car and truck wheel lines to insure quality production at reasonable cost.

AXLES

Spring housings for front wheel suspension units are blanked and formed in halves, then flash welded in heavy-duty semi-automatic machines. These housings later are normalized and machined, then tested for leaks

WELDED HOUSINGS FRONT AND REAR

THROUGHOUT the machining and assembly lines devoted to the manufacture of front and rear axle units for Chevrolet cars and trucks are found repeated examples of careful planning and tool engineering that have resulted in manufacturing economies and product improvement. Full use is made of modern equipment and accessories to insure accurate production of the required parts with the least amount of fatiguing hand labor. In many instances, special accessory equipment, such as multiple-spindle drilling and tapping heads, has been applied to standard machine units, permitting retooling for a new model quickly and economically.

Front and rear axle assemblies for current model passenger cars and trucks, as well as similar units for previous models, are manufactured by the Gear and Axle Division in Detroit. Here 11,000 employees use almost 5,800 machine tools to produce a normal load of 250 front and rear axle units per hour for current model passenger cars and 50 of each unit per hour for Chevrolet trucks. The machining groups and assembly lines are joined by more than 8½ miles of conveyor lines in the four buildings to insure smooth flow of component parts.

Overhead, chain-type conveyor lines from which parts are suspended on special hooks are used throughout the Gear and Axle Division to transport the parts from operation to operation and through washing machines. These conveyor lines travel overhead, with dips to bring the material to work levels where needed, thus serving as storage space for reserve parts and keeping the floor area clear for free movement of men and materials in process among the machine units on the floor. Conveyor line speeds are timed for the part being conveyed; one line in particular operates at a very slow speed in order to provide curing time for the rubber-mounted spring support units used on rear-axle assemblies.

Front Axle Units

Massive flash-welding machines join drawn and formed sections to make the king pin support bar and the front spring housings that go into the assembly of the front axle member for passenger car models. The king-pin support member is blanked and formed in two halves from sheet steel and then flash welded in semi-automatic machines having close control of welding temperature and time.

Reinforcements for the king-pin support are assembled and welded,

then tested. Following this operation, the upper and lower halves of the king pin support are assembled in heavy-duty machines and flash welded. This operation requires two men. Following the welding operation, flash is trimmed at one end in a No. 78 Toledo press, then the unit is reversed and flash is trimmed at the other end in a second press. Yokes, made in another series of operations, then are welded to the king-pin support member in one of three No. 81 Federal flash welding units.

After the assembly is straightened and checked for length, the yokes are arc welded along the upper edges and radius, next the inspection department carefully checks all of the welds on the unit. Assembly then is put through a normalizing cycle in a furnace located directly in the machining line. After being allowed to cool, normalized assemblies are painted with a drawing compound and the locating bosses are coined in a No. 97 Toledo press. This press is equipped with a special fixture to locate the unit so that the bosses will be in correct relation with the rest of the assembly. Coined yokes are straightened and checked on a fixture.

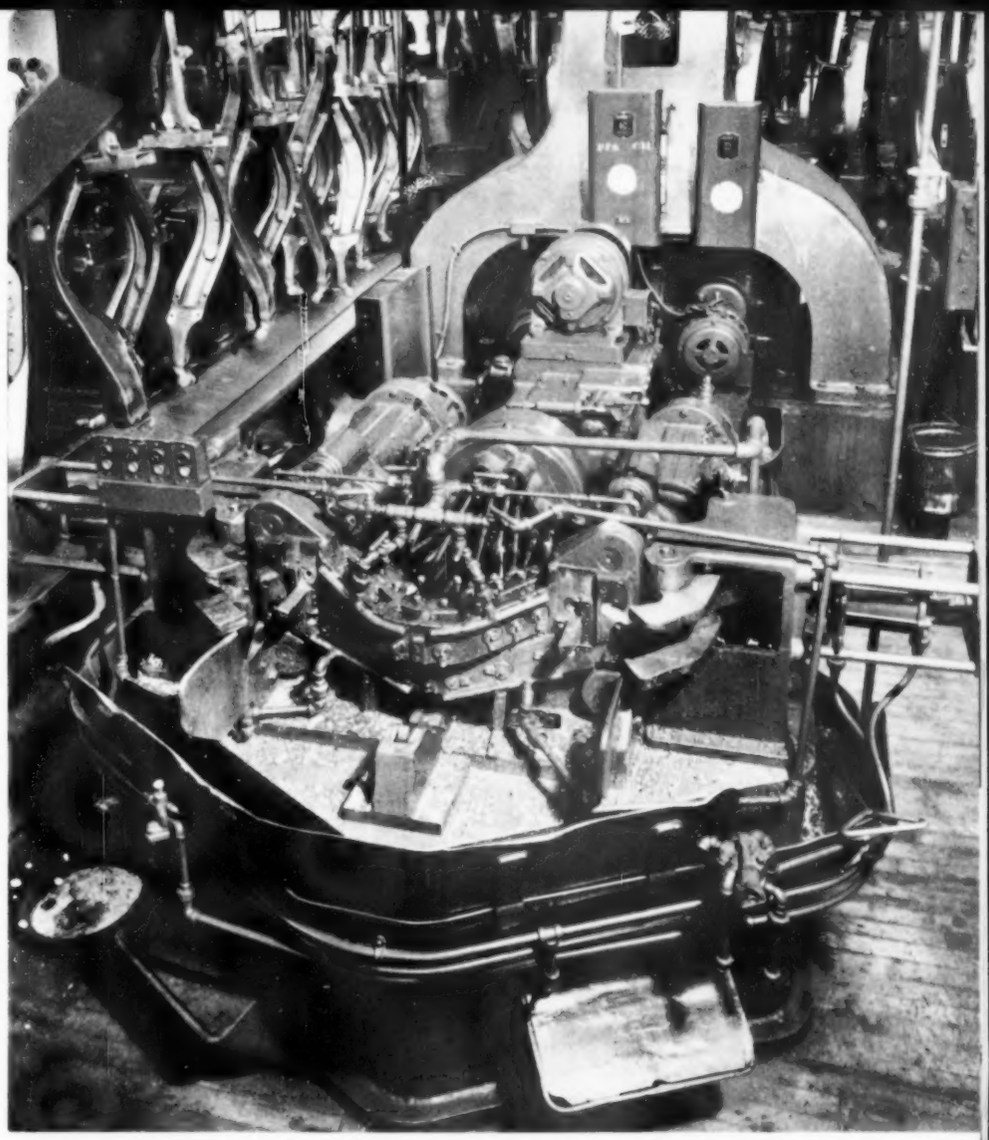
Two Colonial hydraulic surface broaching machines are located in line for an operation which brings the top faces in correct relation to the angular faces on the support assembly. Pilot holes are drilled in special Krueger drilling machines, then four 15/32-in. holes are drilled in each end of the king-pin support assembly while twelve 0.352-in. and two 0.289-in. holes are drilled in the body in one of three special multiple-spindle machines developed and built by Chevrolet tool engineers.

Four holes next are pierced in the bottom of the unit in a No. 78 Toledo press, then the support assemblies are delivered to a line of No. 2B Edlund sensitive drill presses where two tap holes are drilled on the back side in one operation. These two 3/8-24 holes are tapped in No. 2X Garvin tappers mounted in pairs on the machining line. Davis-Thompson milling machines are used to rough straddle-mill the yokes at each end of the support assembly, following which the entire unit is checked for straightness.

The support assemblies then are delivered to special three-way Ex-Cell-O drilling machines where the king-pin holes are drilled and reamed automatically. No. 2B Edlund sensitive drills set in tandem next drill two grease cup holes through both ends of the assembly. These four grease-cup holes next are tapped and the king-pin holes are rough and finish reamed. Inside of the yokes are finish milled in Rockford Rigidmils, following which the king-pin holes are finish counterbored and chamfered on the inside in special Natco two-way machines. Hall Planetary mills machine the spring lock slot in the counterbore of each king-pin hole, and king-pin holes in both ends then are burnished in one of four sensitive single-spindle drilling machines mounted in line at the end of the machining group. The final operation on these support assemblies is to burr the inside faces of the yoke with a file. A hand-straightening fixture is provided to permit slight adjustment of any units that do not quite meet inspection requirements.

The spring housing, in which are assembled the springs, wheel-spindle and other parts to form the front wheel suspension member, also is blanked and formed from heavy sheet steel, being made in two halves. The halves are assembled and flash-welded to form right- and left-handed units in semi-automatic Taylor-Winfield machines equipped with automatic control of welding temperature and time. A double die mounted in a No. 70-D-48 Cleveland press is used to trim the welding flash on the outside and to broach the inside of each housing. These housings are wire brushed on the inside and are carefully inspected for any imperfection of weld. Following this operation, the bottoms are coined and the thread space sized in separate No. 663 Toledo presses. Then the housings are delivered to a machining group where all necessary machining operations are performed. Located in the machining line is a conveyor which carries the housings through a normalizing furnace, following which the units are water-tested for leaks.

Adjoining the machining lines that produce the king-pin support units and the front spring housings are individual groups in which are made the various items that are assembled



Twenty-two holes are drilled in king pin support assemblies at one time with this Chevrolet-built machine. In the background is a conveyor line carrying semi-finished supports to other machining operations

in or on these units to complete the front spring and wheel hub assembly for passenger car units. Brake shoe links, for example, are made in both right- and left-hand units for the forward and reverse brake shoes, being blanked from rolled stock. End of each roll is trimmed in a No. 104-A Bliss press to permit the sheet to enter progressive dies set up in one of two 150-ton No. 6150-A Bliss "Hi-Speed" presses. Punched links are coined in a No. 6½ Toledo press, and the holes in each end of the link are then reamed in No. 4-B Edlund drill presses equipped with two-spindle heads. Helical reamers are used for this operation to permit high-speed reaming without excessive tool breakage. All brake shoe links are zinc plated automatically.

Brake shoes, both for front and rear axle assemblies, are produced in the building devoted to the rear axle unit. These shoes are formed from T-shape sections and are rolled to shape in special Yoder rolling machines, following which the web and radius are coined. The ends next are clipped two at a time in a No. 6½ Toledo press. The ten brake lining rivet holes are pierced in a No. 78 Toledo press, following which five holes are pierced and shaved in the web, two brake shoes being handled at each operation. Following the piercing operations, the web and radius are coined and the web holes are reamed. These reamed holes are burred and the brake shoes are hung on a conveyor for delivery to a zinc-plating tank, which requires three men for a normal operating load.

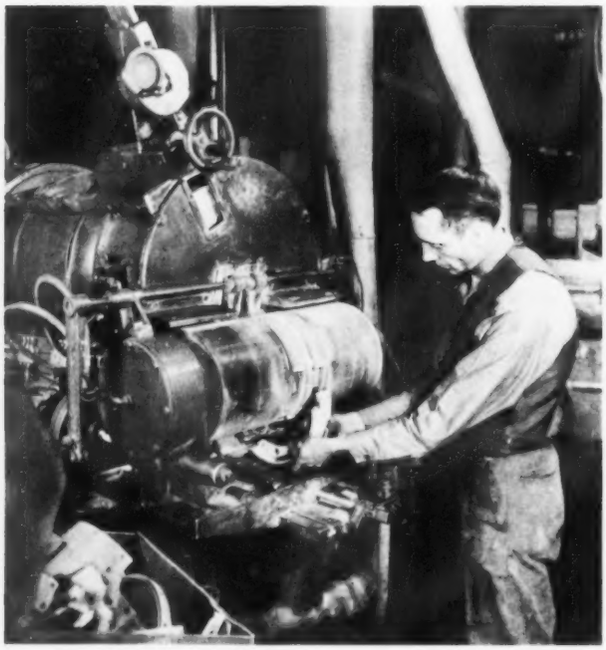
Front spring and housing assemblies for right- and left-hand ends of the front spring suspension unit are assembled in a group in which are located separate work benches and a continuously operating conveyor assembly line. Included in this group are two special Rehnberg-Jacobson machines which sub-assemble 49 needles to a shaft inside a clamp ring for a needle bearing that is included in the assembly. These bearing units are cleaned in another special machine and then, later, are assembled to the bearing in a third special Rehnberg-Jacobson unit. At the end of the assembly conveyor line, the front spring and housing assemblies are removed from the conveyor to an inspection bench where each unit is tested for spring tension in a special fixture and then is water-tested for leaks in a fixture which is submerged in a water tank. Following approval by the inspection department, an adjusting plug lock is assembled to the housing at a work bench, filler plugs are stamped and assembled, then the entire unit is passed to the suspension unit assembly line.

Here, the king-pin support member is removed from an overhead conveyor to rails where pipe plugs are inserted and the member then is loaded on the assembly conveyor. Along this final assembly line, unit assemblies are mounted on the king-pin support member and necessary adjustments are made. A special gage is used to adjust the brake shoes, then after assembling the necessary bearings, brake drums are removed from another conveyor and assembled to the wheel spindle. Before removal from the final assembly line, each front spring suspension and wheel hub assembly passes through a painting unit where paint is flowed from nozzles over the entire assembly.

Rear-End Gears

The building devoted to the manufacture of the third-member assembly in the Gear & Axle Division includes what is said to be one of the largest gear cutting departments in the world. In this group are 477 gear cutters, 9 pinion burnishers, 28 gear and pinion lappers and 65 gear test stands. This makes a total of 579 machines devoted to the cutting and testing of spiral hypoid drive gears and pinions, differential pinions and differential side gears. Preliminary operations on these gear units require, of course, a large number of standard and special manufacturing units, each machine having been selected for the particular operation to be performed.

All hypoid drive pinions and ring gears for passenger car and truck rear ends are machined from forged blanks, which are delivered in freight cars from the Forge Division. Passenger car ring gears are forged from S.A.E. 4615 steel, while truck ring gears are of S.A.E. 2315 steel. These



After the brake lining has been riveted to the shoes it is ground to a true radius on this continuously-operating grinder. The dust exhaust system discharges into a water tank

Finished front wheel brake drum and hub assemblies are carefully balanced before delivery to the final assembly line. A nearby lathe removes metal from the rim to balance the drum

and the drive pinion forgings are delivered direct to the heat-treating department for annealing before they are machined. Pusher-type, gas-fired furnaces are used for this operation, the forgings being annealed at 1,650 F. Approximately 6,000 gear sets for passenger cars and 1,150 truck gear sets can be produced in a 23-hour day when the plant is working at normal capacity.

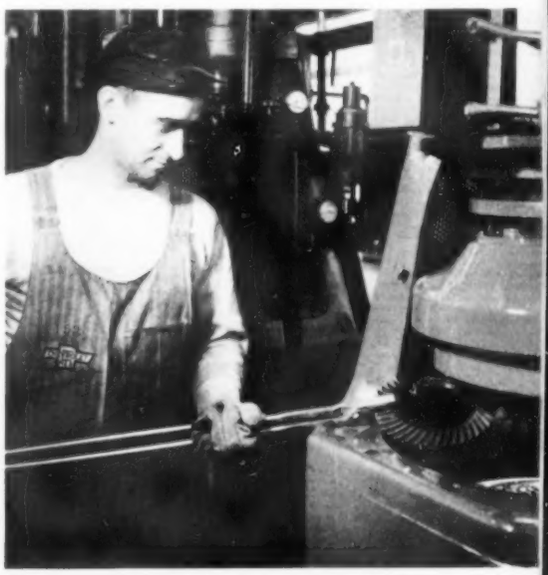
Annealed gear blanks, received from the heat-treating department in tote boxes, are delivered to one of two machining lines which parallel each other and are separated by a continuously operating conveyor line on which the semi-finished gear blanks are hung following each machining operation. Inspected blanks are delivered by hand truck to Gleason No. 11 hypoid spiral bevel ring gear roughing machines, then to Bilgram shaper-type chamfering machines where one side of the outside end of each tooth and the opposite side of the inside end of each tooth is chamfered to remove any burrs produced by the roughing operation. This machine cuts one tooth at a time and indexes automatically.

Rough machined blanks are delivered by truck to No. 11 Gleason single-cycle hypoid gear finishers, then to a washing machine prior to being checked in No. 18 Gleason bevel gear test stands. The testing operation consists of painting the teeth with rouge and running the gear with a pinion to show tooth face bearing. Pressure is applied by hand brake and is indicated by an ammeter in the motor circuit. Finished ring gears go to the heat-treating department.

Machined ring gears are normalized in Holcroft gas-fired furnaces, following which the backs of the gears are burred at floor-stand grinders. They then are packed in carburizing boxes with "Perilite" carburizing compound and are passed through Holcroft automatic gas-fired furnaces to obtain a 0.043-0.048 in. case on the passenger ring gears and a 0.060-0.065 in. case on truck ring gears. There are four zones, each of the same length, in these carburizing furnaces and temperatures of 1,600, 1,650, 1,700 and 1,675 F. are maintained in each succeeding zone. Once the loaded pots are placed on the apron of the furnace, operation is automatic. After being dumped from the carburizing pots, passenger ring gears are quenched immediately in Gleason presses, while truck ring gears are quenched in an open tank on hooks, washed and then rehardened in an electric pusher-type furnace before being quenched in a Gleason press.

Following the quenching operation, all ring gears are washed and drawn at 325 F., then shot blasted with No. 90 grit shot in a rotary table Wheelabrator. This shot blast unit is fitted with fixtures which hold one ring gear and one pinion in each position, the conveyor lines carrying heat-treated and drawn ring gears and pinions

Hypoid spiral bevel ring gears for Chevrolet passenger cars and trucks are annealed, then put through a series of machining operations that ends on one of a number of Gleason No. 11 single-cycle gear finishers. All operations are frequently checked to insure accuracy

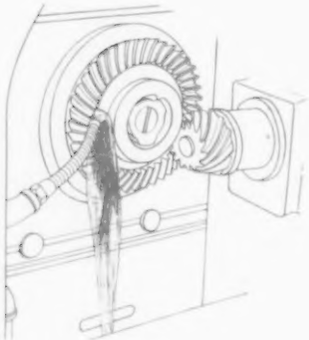


Ring gears are carburized, then quenched in Gleason presses. Next they are drawn at 325 F. and shot blasted before being 100 per cent file tested for hardness

Conveyor lines bring finished parts and sub-assemblies to the final assembly groups. Here a conveyor delivers parts to the front spring suspension unit assembly group

All sub-assemblies and other component parts for the third member are delivered by conveyor to the final assembly group. Here "hi-cycle" tools are mounted in pairs on hangers suspended from the ceiling, and are used for running in and tightening bolts and nuts in the assembly

Rear axle shafts and truck steering knuckles are threaded in 1½-in. "Landmaco" multiple-spindle machines to close pitch tolerances



meeting at this point. Following the shot blast operation, all ring gears are 100 per cent file tested for hardness and checked for warpage with a 0.002-in. feeler gage under the back of the gear.

Returned to the machine shop on porcupine trucks, hardened ring gears are ground on the outside diameter in 10 x 18 in. Norton grinders, then the bore is internally ground and the gears are carried through a washing machine on a chain conveyor. Gears next are paired up with pinions in Gleason test stands and each pair is lapped together. Lapped gears and pinions are washed and 25 per cent are rerolled in test stands to maintain control of the lapping operation.

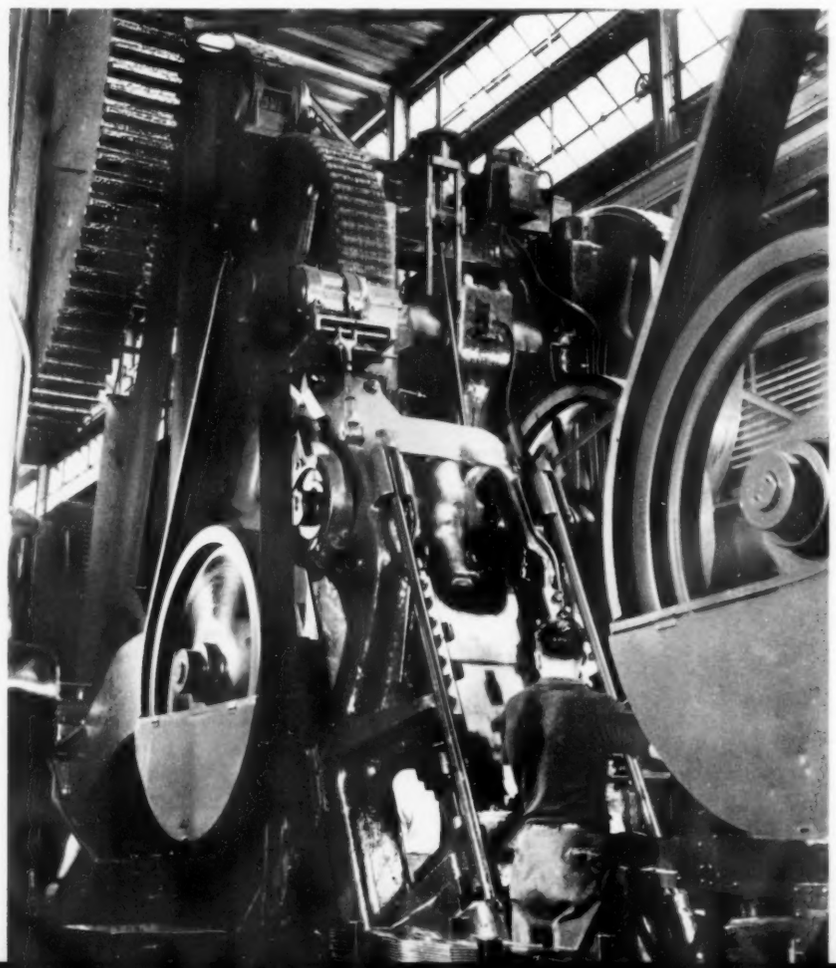
Hypoid Drive Pinions

Annealed spiral hypoid drive pinion blanks are milled to length in a Davis & Thompson miller, then completely machined and tested before being delivered to the heat-treating department for hardening. These pinions are normalized in a Holcroft horseshoe-type gas-annealing furnace then loaded in carburizing pots similar to those used for ring gears. These pots then are passed through the same carburizing furnaces as are used for ring gears and the pinions later are quenched in oil, drawn and washed as well as shot blasted in a cycle that closely parallels that previously described.

Hardened pinions, upon being returned to the machine shop, are lapped in both centers, then straightened in a 15-ton Metalwood press and checked for run-out before finish grinding the bearing surfaces and polishing the large bearing surface for the roller bearing fit. Then they are lapped with matching ring gears and gear sets are hung on a conveyor for delivery to the bearing assembly group.

Differential side gears, also machined from forged blanks, are first drilled in three-spindle heavy-duty drill presses and the splines are broached in a No. 3 Oilgear hydraulic vertical broaching machine. Blanks next are rough and finish turned and the splines are rebroached before the teeth are cut and checked. Pinions then are sent to the heat-treating department. Here the differential side gears are annealed and cyanide hardened and quenched. Upon return to the machine shop, these gears are ground on the hub and back, as well as the counterbored portion. The back of each gear is polished in a three-wheel Hammond automatic polishing

Rear axle housing halves are blanked, then delivered to this press where each end of the blank is coined. Subsequent operations form and trim them before welding



machine and each gear hung on a conveyor which carries it through a washing machine.

Differential pinions are drilled, reamed, formed, chamfered and cut off in 3-in. Acme four-spindle automatics, then delivered to the gear-cutting department where the ten teeth are cut. These pinions also are cyanide hardened and quenched, then they are washed and drawn in Homo furnaces before being returned to the machine shop where the back radius is ground in a No. 2 Oakley machine. Later, this radius is polished in a three-wheel Hammond automatic polisher.

Malleable iron differential carriers, bearing caps and differential cases are completely machined in groups located near the third-member final assembly line. Most of the turning, boring and facing operations are performed in standard units, while many of the drilling, reaming and tapping operations are performed in special, multiple-spindle machines arranged for the particular operation.

Propeller shaft coupling and front ends are pressed into the tubes in a special Ex-Cell-O press which is hydraulically operated. These shafts then are straightened in specially arranged straightening benches before both ends are arc welded automatically in Chevrolet-built machines. Flash is turned from the welds in standard engine lathes, then each tube is torque tested and straightened. The spline ends next are rough and finish ground in separate No. 3 Cincinnati machines and the splines are hobbed in No. 12 Barber-Colman units. Following drilling and countersinking operations, each shaft is straightened and dynamically balanced at the rate of ten pieces per hour for each dynamic balancing machine.

Both passenger car and truck third-member units are assembled on the same conveyor line, to which all sub-assemblies and individual component parts are delivered by conveyor. Hi-cycle tools are used for running in and tightening the cap bolts which hold the various units together. These electric tools are suspended near the position where they are used and separate generators provide necessary frequency changes where different speeds are required. Assembled third member units are hung on an over-head conveyor which delivers them to a soundproof test room. There seven test stands are used for testing each unit for tooth bearing and noise. Rejected units are returned to a repair line and those units that have been passed by the inspection department are transferred to a second over-head conveyor which carries the unit to the rear-end final assembly line in another building.

Axle Shafts

Axle shafts are delivered from freight cars to the machine shop by a separate conveyor system. These shafts are straightened in one of several Metalwood presses equipped with sensitive control. Prior to hardening, the shafts are turned on the outside diameter of the flange, broached to length, centered on one end and then sent to 10-in. Bullard Continumatics where the spline end is rough turned and the two bearings and one side of the flange are roughed. Shafts then are returned to the same conveyor line, which delivers them to the heat-treating department. Here two men remove the shafts from the conveyor line and place them on a furnace conveyor unit which carries them through the heat section of a special Holcroft furnace, then dips them in quenching oil and raises them to an upper level of the furnace where they are drawn at the proper temperature. Shafts returned to the loading position are transferred to another over-head conveyor and carried to a Pangborn sand

Housing flanges and spring seat brackets automatically are arc-welded in position on the rear-axle housing in this six-head, specially-built welder. Each welding head is served by a separate spool of coated electrode wire

Wheel shafts and rear axle brake drums are sub-assembled on this rotary fixture before the drums are finish bored and honed. Special retainer plates are used, these being removed on the final assembly line

All rear-angle sub-assemblies and other component parts are fed to this final assembly line. Here each operation is performed in a carefully planned sequence. The continuously moving conveyor delivers finished units to a second conveyor line where they are carefully inspected before being painted

blast unit where No. 20 steel shot is used to remove scale. Each shaft is checked for hardness on the flange and spline ends in separate operations, using Gogan Brinell testing machines. They then are piled in tote boxes for delivery by electric truck to the final machining group.

Following a straightening operation, seven grinding operations, one turning operation and drilling and tapping operations are required in addition to several milling and splining operations before completion of each axle shaft. Cleveland rotary, multiple-spindle hobbers are used for spline milling one end of each shaft. Rear axle bearings are pressed over the shaft, then the gasket and brake drum oil deflector is assembled and six bolts are placed by hand in the shaft flange. These bolts are pressed to position in one of two Toledo presses and the shaft assembly is delivered to the shaft and brake-drum group. Here the shaft is set in a turntable and the drum is assembled to it with a temporary plate. Drums then are finish bored in Sundstrand lathes and honed in specially designed machines, following which the shaft units are inspected and delivered by conveyor to the final assembly line.

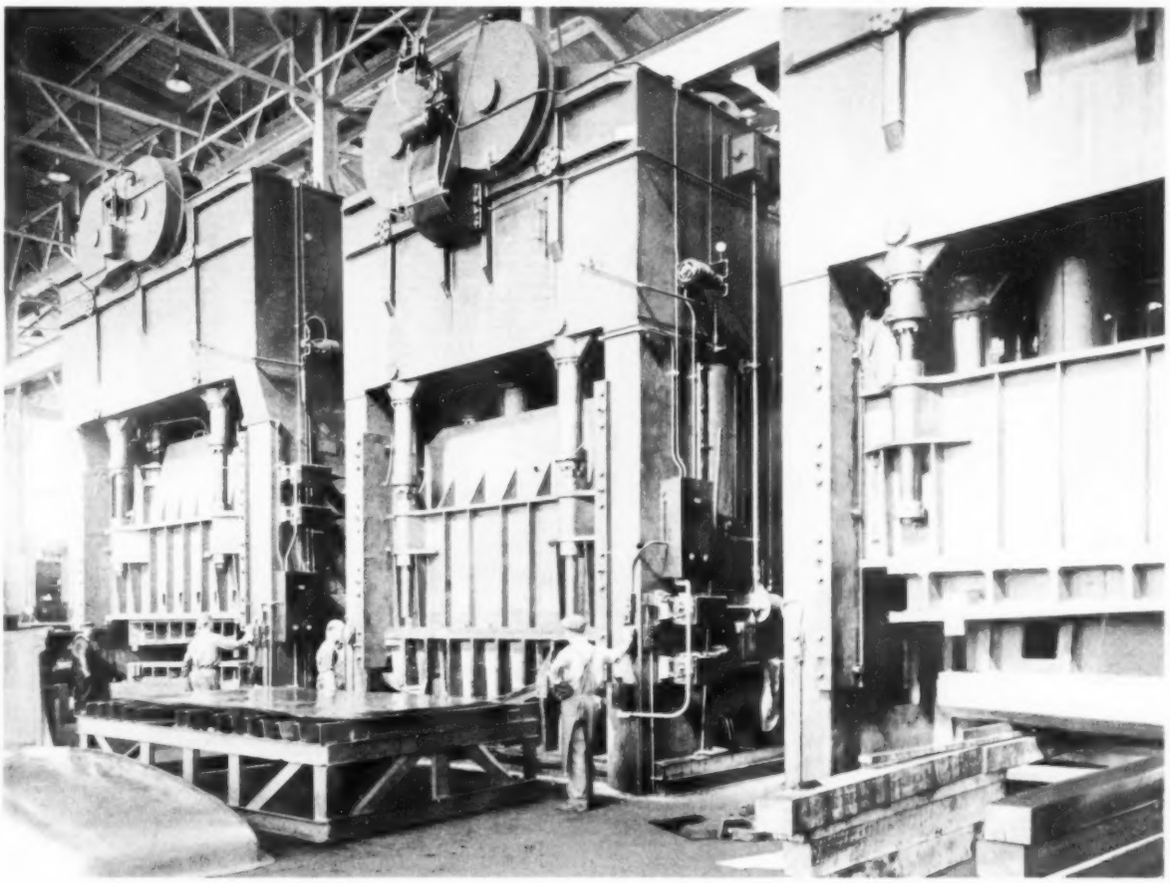
Welded Axle Housings

Rear axle housings are formed and welded from sheet steel, two duplicate halves being blanked one at a time in No. 310 Bliss presses, and then passed down a press line where each half is put through the following operations: (1) swage both ends; (2) first form center; (3) second form center; (4) third form center; (5) first form contour; (6) second form contour; (7) trim contour. Two halves then are assembled together in the jaws of No. 293-B heavy-duty Metro unit and are flash welded together. Following this operation, the housing unit is placed in a No. 308 Bliss press where the flash is trimmed from the outside, after which the spring seat diameter at each end is sized in a second press. Situated next in line are three arc welding booths where seams in the housing unit are arc welded. Following this the welded seams are ground and the flash is trimmed from the inside diameter. The final operation on these housings is to flatten the banjo in a No. 4-K Cleveland press.

Housing flanges are pressed on each end of the axle housing in Oil-gear horizontal presses, then two spring seat brackets are located and spot welded in position. A six-head automatic arc-welding machine next welds the two flanges and spring brackets in position. The housings then are straightened and 100 per cent inspected. A conveyor next delivers the housings to two-way Barnes horizontal drills where the housing is drilled, bored and reamed for the shaft bearing and the face of the flange is turned. Column-type drill presses are used to drill ten holes on each side of the banjo following a facing operation, which is performed in a No. 422 Baker drill.

Completed housings are delivered by conveyor to a machining group where the bearing holes are burred and then studs are assembled and pressed in position in a No. 77 Toledo press. Following this operation the inspection department carefully checks each housing and then a No. 112 Defiance drill press fitted with a multiple spindle head taps ten holes in one side of the banjo This machine is equipped with a special bracket which oils each of the ten taps automatically while the machine is being reloaded. Machined housings then are washed on a conveyor and rattled.

COMMERCIAL BODIES



Huge Clearing presses exert pressures up to 1,500 tons to draw the turret top for the 131½ in. panel body. Dies for such an operation weigh up to 40 tons

A PLANT THAT PREVENTS BOTTLENECKS

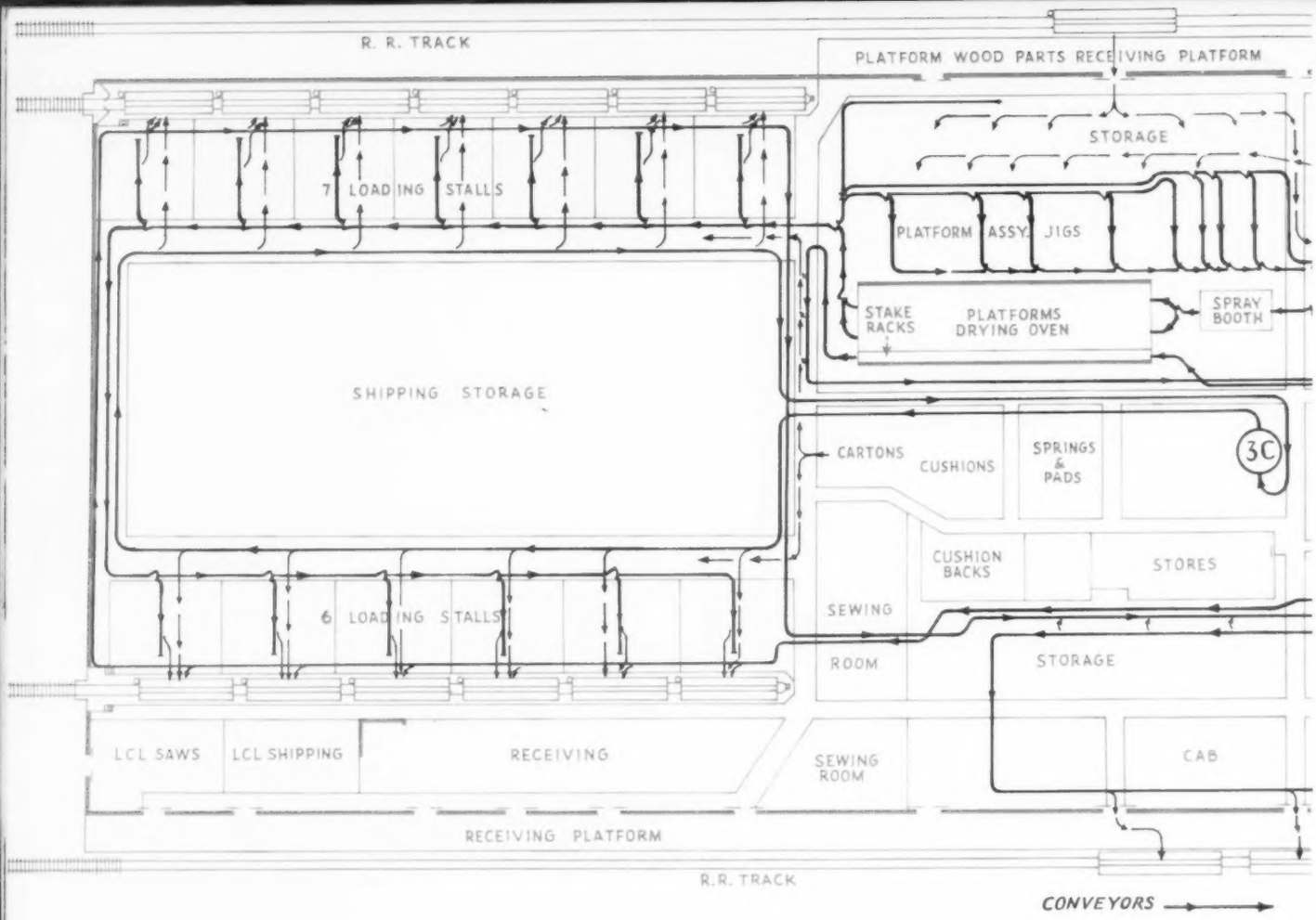
CHEVROLET'S Commercial Body Division was established in Indianapolis in 1930, but in the short span of six years an entirely new plant had to be built and equipped. Floor space is the same as before—500,000 sq. ft.—but the new plant is especially arranged for commercial-body production, and its capacity is twice as large.

What is the secret of this plant that permits it to produce 40 models according to seasonal demands, and to do so without bottlenecks and large inventories of finished parts? A complete answer cannot be given without study of the management set-up and of the plant layout and methods.

At the Indianapolis plant commercial car bodies and truck bodies are produced in sub-assemblies so far as possible and shipped knocked down to the ten domestic assembly plants and to foreign assembly plants. There has been a big growth in demand from abroad for commercial car bodies during the last three years, because foreign companies cannot compete with the complicated and streamlined American designs. Foreign concerns are not in a position to spend money for expensive tooling involved in the new all-steel construction.

With customers hauling or delivering all kinds of loads under all sorts of conditions the first big job is to find out what domestic and foreign buyers will want and when they will want it. A flood in the Middle West, for example, can make a heavy and immediate demand for a particular type of body, and it behooves the plant management to know such things and to act promptly. To take care of such eventualities, a well integrated production philosophy must be established.

At Indianapolis all parts are made into sub-assemblies so far as possible —side panels complete—tops with insulation and cross bows in place—complete seats—complete floors or platforms — complete doors — and these must be interchangeable so far as possible in kindred lines or types. Production lines are worked out to produce these sub-assemblies, and in many cases the equipment is installed to do the sub-assembly work more efficiently than obtains elsewhere.



Moreover, sub-assemblies are designed so that components of 25 bodies can be loaded into one automobile car for shipment to branch assembly plants. Other producers ordinarily ship three complete bodies per car with consequent higher shipping costs.

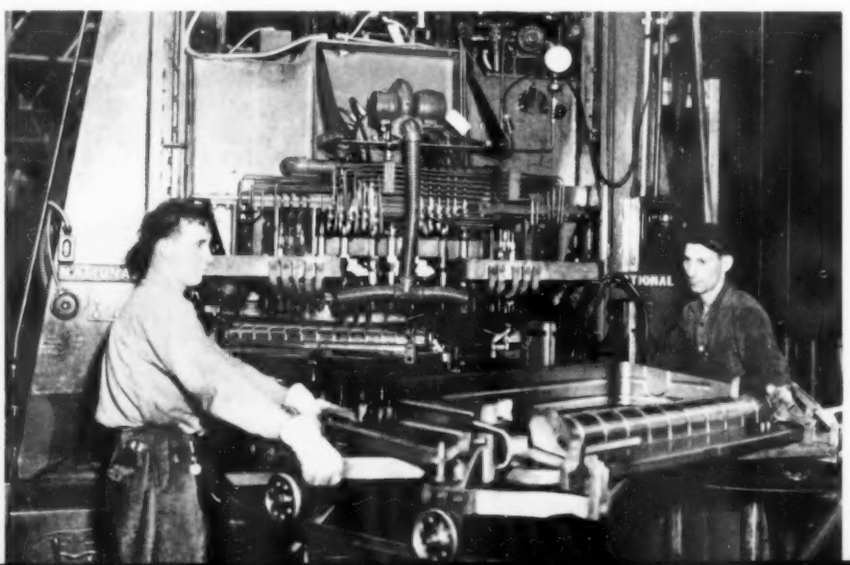
Under the General Motors system of decentralized units, the Commercial Body Division operates like a separate company. The plant manager is principally charged with producing the finest possible panel and truck bodies, in order to assist Chevrolet in maintaining leadership in a highly competitive truck market. Once the yearly program is approved by the central authorities, he is practically "on his own."

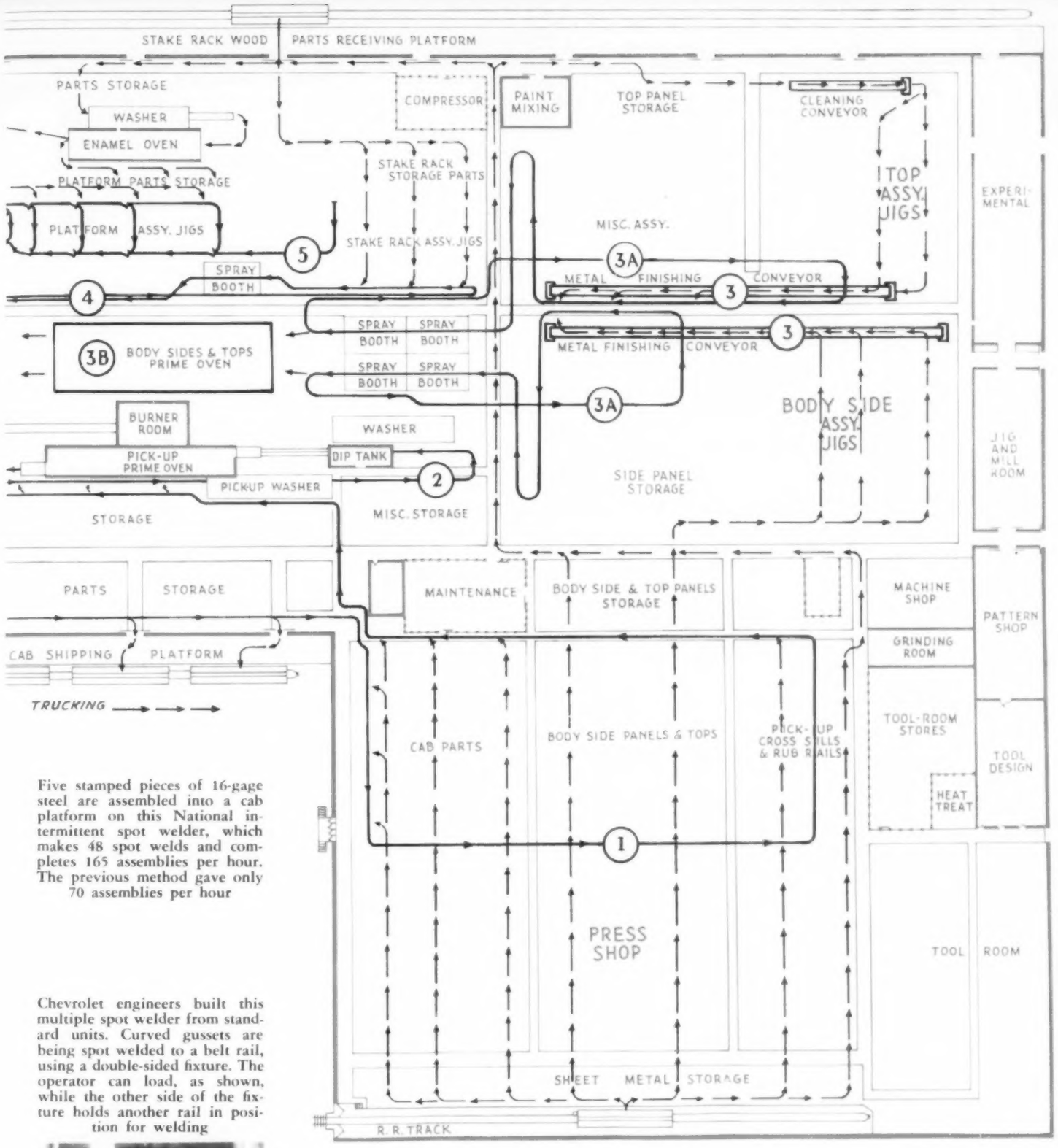
Naturally the plant manager must organize his plant on the same lines as any other manufacturing enterprise. Market surveys, product design, tool design, manufacture, inspection, purchasing, shipping—all such functions are handled by his staff. In short, he is responsible for the profitable operation of a plant employing 1,700 men in good times.

The starting point of his responsibility is to see that new designs are worked up for the forthcoming model year. A field survey is made under the direction of the body engineer, contact men being sent to the major cities to get the views not only of dealers but of truck buyers as well. These men also visit the truck service departments of dealers to find any possible defects or opportunities for improvements. In this way the product is designed actually to suit the needs of the buyer and not alone to please the sales department. Contact is also made with the Truck Sales Division, General Motors Corporation, in Detroit, in order to keep thoroughly abreast of developments and requirements in the commercial body and truck field.

All of this field-survey work is done far enough ahead so that the body engineer will be able to make experimental drawings and models. While these are in preparation the body engineer maintains daily contact with the other two engineers—tool engineer and plant engineer. The tool engineer advises the simplest and cheapest method of fabrication whereas the plant engineer is responsible for ways and means of putting the parts together in a clean, workmanlike manner.

As the new model program progresses, the entire staff meets to iron out difficulties by the conference me-



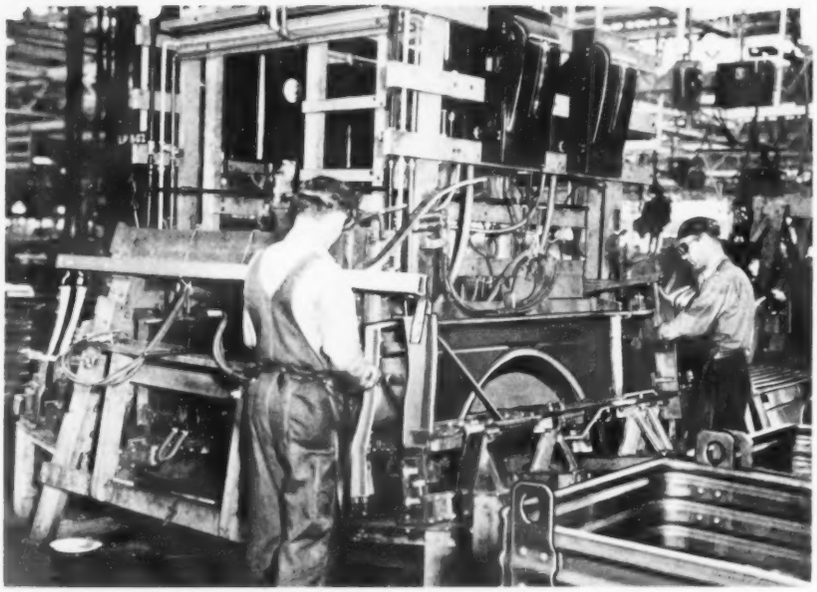


Five stamped pieces of 16-gage steel are assembled into a cab platform on this National intermittent spot welder, which makes 48 spot welds and completes 165 assemblies per hour. The previous method gave only 70 assemblies per hour

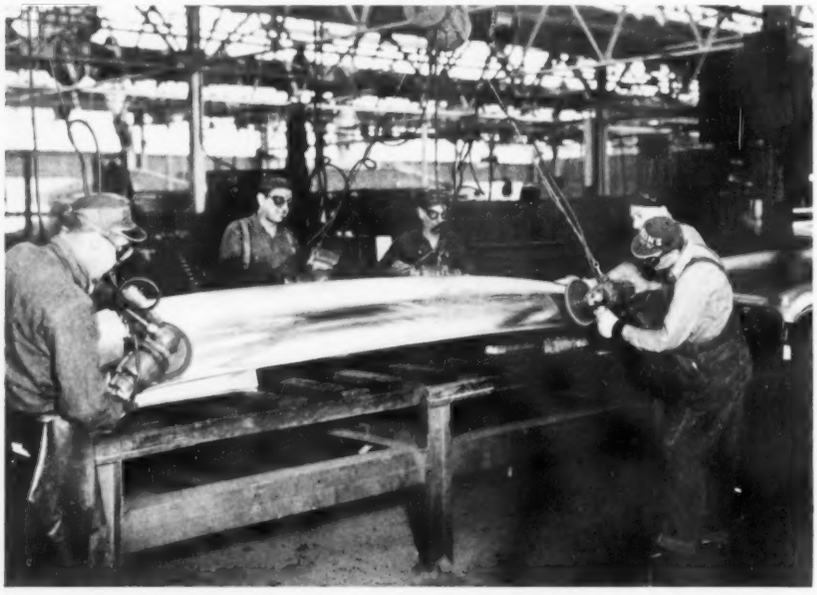
Chevrolet engineers built this multiple spot welder from standard units. Curved gussets are being spot welded to a belt rail, using a double-sided fixture. The operator can load, as shown, while the other side of the fixture holds another rail in position for welding

MATERIALS HANDLING LAYOUT FOR COMMERCIAL BODIES

(1) Press shop conveyor, (2) Pick-up conveyor, (3) Metal finishing conveyors for tops and side panels, (3A) Painting conveyors for tops and side panels, (3B) Conveyor-type drying oven for tops and side panels, (3C) Final assembly conveyor for tops and side panels, (4) Stake rack conveyor, (5) Platform monorail



Side panel assembly jigs are equipped to make rights and lefts on opposite sides. These men are placing the inner panel and stiffening members, and the outer panel will soon be placed in position. Hydraulic pressure gun welders are favored



Metal finishing and putty glazing of turret tops for commercial bodies are done to the same standards as for passenger cars

thod. The men directly affected are the plant manager, the three engineers, the production superintendent, the chief inspector and the materials supervisor. All play a vital part in the ultimate achievement. The materials supervisor may be able to suggest a cheaper and better material; the chief inspector may suggest improvements in methods of locating the pieces; the production supervisor knows the equipment available and the output that may be expected from it. The time study supervisor and the die engineer can aid because of their intimate knowledge of shop equipment and methods. Assistance is obtained from the Art and Color Section, General Motors, for styling commercial bodies in closed models.

When the final program of the body engineer is approved by the plant manager, it is submitted to the chief engineer at Detroit, and to the manufacturing and sales executives there. After their approval is obtained, the purchasing agent establishes sources of supply for raw materials and semi-finished material such as steel, other metals, textiles and lumber. There is no hesitancy to buy anywhere, or to buy a part outside rather than to make it if a lower price can be obtained.

At this point the materials supervisor steps in. A monthly schedule for production and authorization to purchase materials is received from headquarters, according to the demands of the branch assembly plants, and the materials supervisor issues materials orders to the suppliers. He is also responsible for shipping parts to reach assembly plants on schedule.

These details of the management set-up give an idea of the planning involved on the execution of the yearly program. The second half of the picture concerns the part played by plant layout and methods in executing orders expeditiously and economically.

Plant Layout and Methods

Let it be said at once that the Indianapolis plant was laid out from lessons learned during the 1930-1936 period, in which the company occupied facilities not especially designed for commercial body production. The principal aims of the management in designing the new plant were:

1. To prevent bottlenecks in production.
2. To provide adequate storage space for parts or sub-assemblies that might be needed in a hurry to meet an unexpected demand.
3. To handle material with a minimum of effort. There are five main conveyors and a well integrated system of industrial trucks and skid boxes.
4. To make up components into sub-assemblies so far as possible, and to equip the plant for such a program.
5. To achieve a definite rhythm in every step of manufacture that would not overtask the men, but instead cause them to work unhurriedly, yet at the same time more effectively.
6. To provide adequate space around machines for storage of work in process, thus assuring neatness and dispatch in getting parts into and out of machines and assembly fixtures.
7. To provide adequate die making and die storage facilities, pattern shops, experimental shops, and tool and assembly fixture design and building departments.

How these aims were carried out can be seen from a study of the accompanying plant layout. There are five main conveyors serving the plant as follows:

1. Press shop conveyor.
2. Pick-up conveyor.

3. Metal finishing conveyor (tops and side panels).
4. Stake rack conveyor.
5. Platform conveyor.

The press shop is divided into three main sections: (1) cab parts, (2) body side panels and tops, (3) pick-up cross sills and rub rails. An interior siding along the outside wall of the press shop permits steel to be delivered to steel storage directly before the three press shop sections. Steel is stacked by the 25- and 35-ton overhead traveling cranes serving the metal storage. These cranes also handle large panel and turret top dies into and out of the presses.

Clear height to the roof trusses is 50 ft. in the press shop to allow room for the huge Clearing presses that form the turret tops and side panels. Four of these machines are capable of drawing turret tops and they are located adjacent to the steel storage. One Clearing press is considered the largest in the industry, since it measures 208 in. between uprights. The press shop is 280 ft. deep to permit considerable flexibility in the length of lines for a given body component or sub-assembly. The practice in these lines is to make as many pieces as possible into a sub-assembly for transfer into sheet metal finishing, storage, or further assembly operations.

Truck cab parts are shipped in the "white", so they are assembled as far as possible in the press section reserved for them and are then hung on the press room conveyor. This conveyor transports them to the cab parts storage adjacent to the cab shipping platform.

In the cab platform press department there are two recent installations of equipment which are indicative of the management's policy of making sub-assemblies so far as possible from component parts instead of shipping them to the branch assembly plant for sub-assembly operations. Both installations happen to be automatic intermittent spot welders. One machine was developed at the plant, while the second machine, a National, is employed to assemble five parts into a cab platform.

The Chevrolet spot welder is a multiple-spot type built up from standard units. In case a model change makes a part obsolete the only portions of this machine that need be scrapped are the fixtures because the standard units can all be salvaged for other purposes. There are several other features of this multiple spot welder such as: the short operation cycle, the low electrical current requirements, and low initial cost.

The short operation cycle is accomplished by designing a two-station revolving fixture into the machine. This makes it possible to unload and load at one station, while the welding operation is taking place at the other station. In conjunction with this, the welding is done on the underside of the revolving fixture. Thus flash and sparks are prevented from harming the operator. He does not have to wear goggles and the operation is quicker since his vision is not impaired. The parts to be welded are moved to the welding points rather than moving the welding points to the work.

Low electrical current requirement is inherent, when low reactance is had on the secondary side of the welding transformer. In the case of this spot welder, both sides of the secondary circuit are brought to the welding points, parallel and adjacent to each other. This gives a very low reactance loss and decreases primary current consumption.

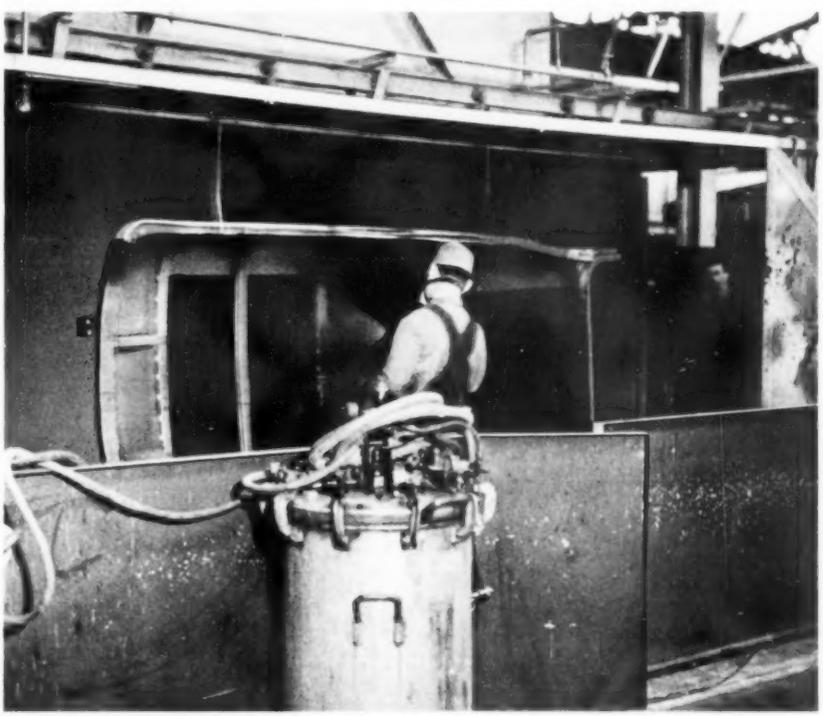
The standard units employed in this machine include welding contractor, weld timer, electric disconnect switch, air cylinders, including an air-operated hydraulic pressure producing unit.

With a specially designed pressure distributing system and electrical timing system, each welding gun is given its individual impulse of hydraulic pressure and the weld is automatically timed for duration. Holding time after the weld is made is controlled as to length. The economy here is that a pressure-generating unit, which operates continuously, is not required. The hydraulic pressure producing unit supplies only an impulse of hydraulic pressure to each individual gun as the timing device actuates each gun.

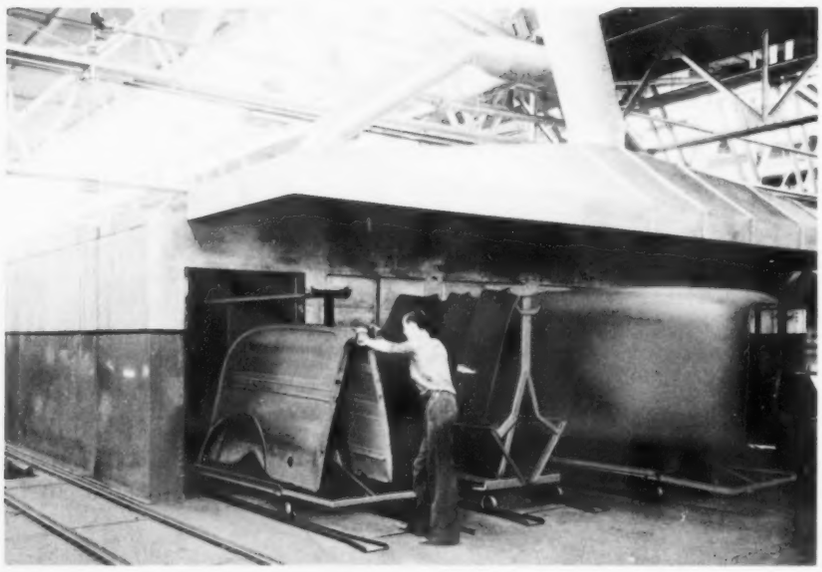
Body side panels and tops are trucked to storage spaces adjacent to the start of the respective assembly lines. Note that these assembly lines feed to the center, where metal finishing, spraying and baking are done in a straight line.

Side panels are built up in perhaps the only such extensive line of jigs employed in the commercial body field. Three sets of jigs, right and left hand, are employed for producing the three lengths of side panels involved. Sets of locating points and pads in the jigs provide for making different models in any one length.

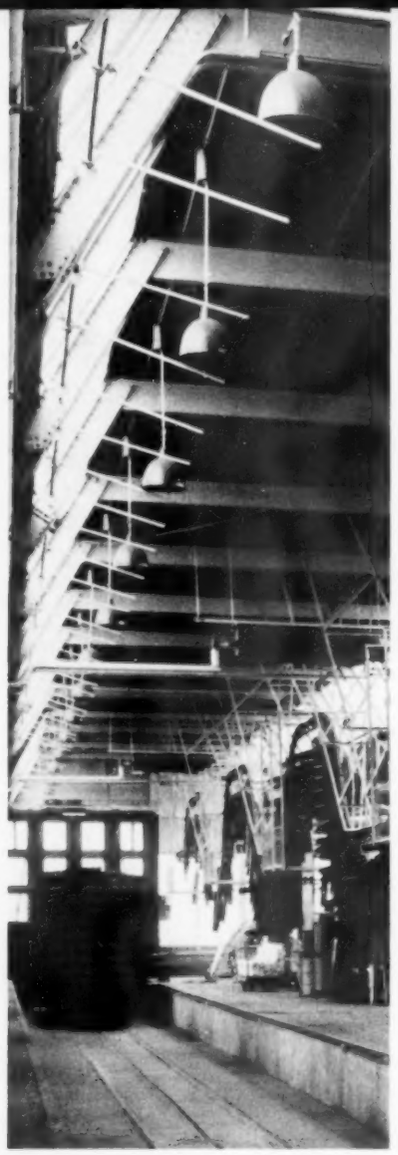
Operators work on the two sides of the assembly jigs to produce right and left hand panels simultaneously. They place the inner panel in position, lay in the stiffening members, and arc weld highly stressed points. Next they spot weld the inner panel and stiffeners at closely spaced intervals. Meanwhile pressed wood panels for heat and noise insulation have been placed inside the outer panel with hardened drive nails. The outer panel is then assembled to the inner panel.



Hydro spray booths are installed to protect the health of the operators and to eliminate fire hazards. A water spray at the bottom of the back wall removes fumes and pigments as air from the room is exhausted through the spray



Side panels and top panels are put on special trucks for a trip through the primer baking oven



Latch plates, striker plates and other hardware are installed on the side panels after they leave the baking oven. Convenient wheeled parts tables assist the operators as they move with the work

The Indianapolis plant prefers to use hydraulic pressure for operating the gun welders at the assembly jigs instead of air pressure. It is believed that hydraulic pressure provides a more sensitive control, and less of a snap action. Moreover they use short-circuit type guns wherever it is possible to design a suitable electrode into the fixture at the appropriate point.

Turret tops are removed from top panel storage and placed on a cleaning conveyor where they are wiped by hand because no satisfactory method has yet been devised for degreasing parts of this size and shape. Roof rails are assembled in a jig, and are taken with the turret top to an assembly welding jig similar in principle to those used for side panel assemblies.

Assembled top panels are taken from the assembly jig to bucks where the insulation mats are placed in position between the roof rails. Next the tops are lifted from the bucks and placed top side up on a slat conveyor in the metal finishing line. Workmen metal finish and glaze tops of commercial bodies just as carefully as is done for passenger cars.

Inspected tops are taken from the slat conveyor and hung on an overhead conveyor that takes them through two hydro spray booths for application of a primer and an undercoat on the inside. The hydro spray booths are open to the atmosphere, and have a water spray near the floor on the side opposite the operator. Air is drawn from the room into the spray booth and down through the water sprays to remove all fumes. It is said that the operators need not wear masks, but they are required to wear a respirator as a safety precaution.

Sprayed top assemblies are lifted

One of the greatest materials handling aids to the plant is the pick up conveyor. Once parts are transferred to it from the press room conveyor, the work is taken automatically through washing, dipping, baking and back to shipping platforms, one of which is shown. The dips in the conveyor permit parts to be taken off at twelve car loading stations

from this conveyor and placed on a special hand truck for a trip through the primer baking oven. When they emerge they are hung on another conveyor to take them to the shipping storage that lies between the two shipping platforms. Side panels go down a similar metal finishing line, through the hydro spray booths, the primer baking oven, and are hung on the same conveyor for assembly of the hardware while moving along to shipping storage.

Stake rack and platform assembly lines involve the use of large quantities of wood with small sheet metal details. For this reason wood parts are received kiln dried, millworked to blueprint specifications and creosoted at a receiving platform on the opposite side of the building from the press shop. Platform assemblies are made on roll-over jigs, and screw driving and nut running are done with high cycle tools to speed production. All sheet metal parts are enameled prior to assembly so that moisture that gets between the wood and metal will not cause hidden corrosion. Platforms are sprayed with black enamel, stakes with gray primer, and they are baked in a combination oven.

Conveyors are used in this plant to lighten the task of taking parts finished in the press department directly to the shipping platform or to transport bulky assemblies through the finishing operations to the shipping storage. They are not employed as in other plants as a means of storing work in process. Much of the handling work is done by special Chevrolet-engined hydraulic lift trucks and steel skid boxes. To conveyorize this plant completely would mean an excessive number of conveyors and a far greater handling expense. The scheme has been to use an intelligent combination of conveyors and trucks. Wide aisles are provided for truck transportation.

A completely equipped pattern shop makes up accurate full-size wood patterns of each section of the body. These patterns are used as guides for making the dies and the assembly fixtures. Tools and dies are made in one department and assembly fixtures in another department.

The die shop measures 100 x 280 ft. to take care of building, dressing and storage of the dies used. Approximately 1,600 dies are made per year and some weigh as much as 40 tons. The larger dies are huge built-up affairs that draw an entire turret top or side panel. Chevrolet uses nickel-cast iron for draw rings and gray iron in the remainder of toggle press dies. Two Keller machines are employed to reproduce dies from models.

ASSEMBLY

A Huck rivet is set in the box frame where no hold-on can be used. The sleeve rivet is put through the bracket and frame, the hydraulic gun grips the center pin and pulls it through the sleeve, upsetting the inner end

Each entry on the telautograph gives details as to whether plain axle or knee action goes on the frame. It also tells just what kind of body, and the color of body, hood, fenders and wheels must go with each frame on the final assembly conveyor

SOLVING THE "PUT TOGETHER" PROBLEM

NEWEST Chevrolet assembling plant at Baltimore, Maryland, is the result of careful planning with a background of years of practical experience. The building is approximately 400x980 ft., one story except for the galleries, and splendidly adapted to its purpose. Its normal output is 60 passenger cars and 20 trucks per hour with a crew of 1200 men. This includes not only the men on the actual car assembly lines but those engaged in the bonderizing, enameling, spraying, sub-assembly of such parts as frames and hoods and the crew that track tests and service the cars ready for delivery to the customer.

Full appreciation of the orderly flow of materials cannot be realized until one sees the great variety of color and other options that go to make up the complete car. All of these problems had to be studied carefully in laying out the plant. A study of the layout will show how the many problems were worked out and will aid in following the assembly routine and methods of the different sections.

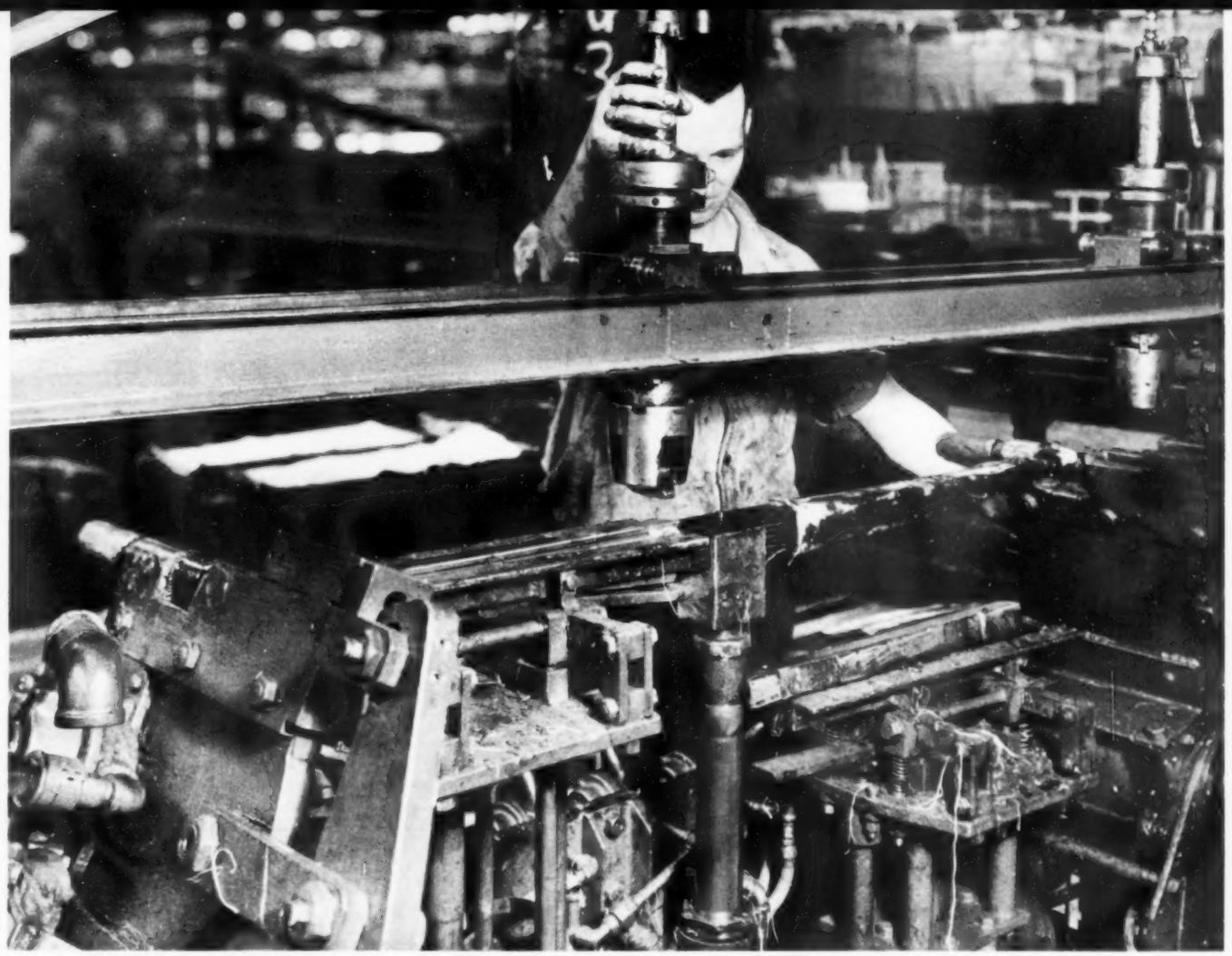
Just inside each sidewall of the 400 ft. wide building are railroad tracks, each delivering materials that will flow toward the assembling conveyor near the center. Motors and other parts, such as transmissions, generators, carburetors and exhaust pipes come in the track at the upper side and are stored in the locations indicated. Front axles, fenders, wheels, radiators and hoods are also delivered to this side of the building as shown.

From the track on the other side come frames, rear axles, springs, truck bodies and cabs and such raw sheet metal as may be needed. Storage spaces for the main parts are marked in the illustration. As in all modern conveyor-equipped plants, the overhead monorail conveyors also act as a limited storage that is always available at the assembly lines.

A study of the various assembly conveyors, which are plainly marked, will help to visualize the way in which the materials flow through the shop, and how the different units are brought to the main assembly line at the proper point. Details of these movements of material are the secret of successful, economical assembly.

Frame Assembly

Beginning with the riveting of side brackets and parts to the side frames, it is of interest to note the box section instead of the usual deep channel. This makes it possible to use thinner steel and so lighten the frame while retaining strength and stiffness. This frame section is made by welding a flat strip across the bottom of



Springs are covered to keep lubricant in and dirt out. A canvas strip, well coated with grease and graphite is put around the spring after it is straightened out by the ram under the center. Then a flexible metal cover is put over the canvas and the edges locked by moving the air-actuated head back and forth along the spring cover

a flanged channel, and comes from the E. G. Budd Company in Philadelphia.

The box section, however, presents a problem that would have been practically unsurmountable without the new Huck rivet, designed to meet just such conditions. For such a section does not permit of riveting the running board brackets, and other connections in the usual manner. No "hold-ons" or "back stops" for the rivets can be used, as in usual practice. The Huck rivet however, solves the problem.

All holes are punched in the frame before it is welded into a box. So it is necessary only to place the brackets on the frame, slip the Huck rivet through from the outside, apply the hydraulic gun and the rivet is set. This is done by holding the rivet head against the bracket while the "gun" grips the center pin or bolt by serrations near the end, and pulls the head into the sleeve until it rolls it over into a good sized rivet head. When the pieces are riveted tightly, the central pin breaks at a point just inside the head.

From here the side frames, matched as rights and lefts, go to the short conveyor line marked "Frame Rivet," which is about 100 ft. long. Beside the starting end of this conveyor is the telautograph. The first body listed on the paper strip is cut off and pasted on the inside of the frame as it starts down this conveyor line. This slip of paper shows whether the frame is for a Master or a Master De Luxe car, and also the style and color of the body and trim.

Leaving the frame riveting conveyor, where they are lengthwise, the frames go to the left on a 150-ft. conveyor which is at right angles, placing the frames crosswise for the assembling of springs and axles. A monorail brings the rear axle assembly to the conveyor on one side, while on the other, front axle or knee action units have a monorail conveyor of their own, to be applied to the front of the frame.

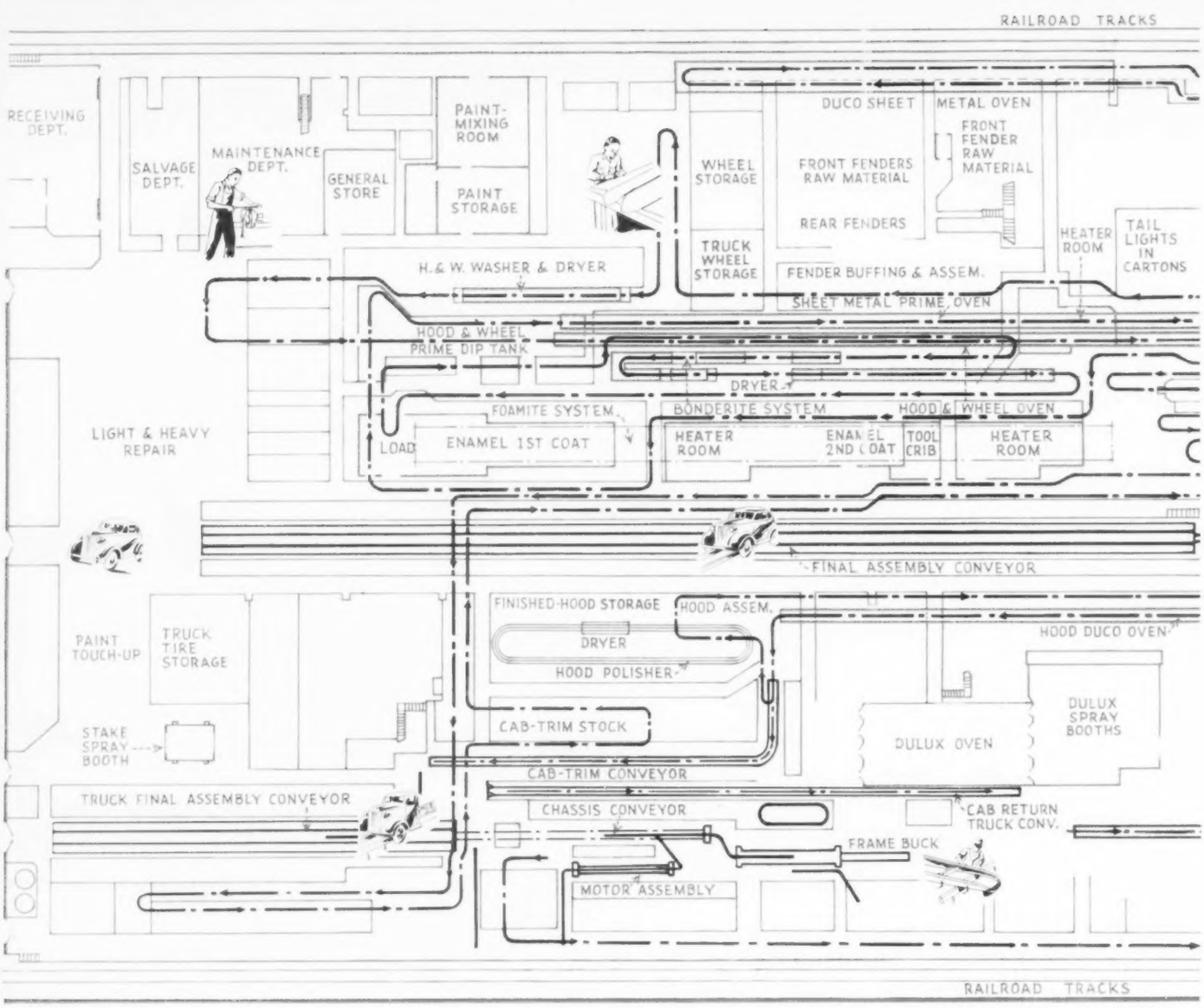
Spring covers, of metal in sections to permit flexing, are applied near the beginning of the axle conveyor. An ingenious machine makes this a simple operation. A graphited canvas lining goes under the cover. Bumpers, gas tanks and other parts are also attached while the frame is on this conveyor.

Somewhat offset from the end of this axle assembly line is the final, or chassis, conveyor. Between the two is a monorail with an air hoist, and here a roll-over method is used that is simplicity itself, plus a bit of skill on the part of the men. There is a knack in turning the frame without undue effort. The experienced men roll the frame and turn it once more in a lengthwise position, with a single easy motion that indicates practice and dexterity.

Motors Feed Into the Line

In the meantime motors and motor accessories have been unloaded from the track on the upper side of the building. Storage space is provided for nearly 3000 motors, which come from Flint and also the new plant in Tonowanda. In addition, the monorail that carries the motors to the motor assembly line, can store quite a number when desired.

Transmissions, mostly from Mun-



CHEVROLET ASSEMBLY PLANT

cie, Indiana, are stored nearby and can use the same monorail as the motors, which is about 85 ft. long. Here the transmissions are bolted into position, the generator, carburetor and breather pipe put in place, and the spark plugs screwed in. Spark-plug holes are protected by thick disks of soft cardboard to keep dirt out of the cylinder, which are quickly removed with a pointed tool and the plugs substituted at a rapid rate.

As the motors go down the line the crankcase receives its supply of oil, and the carburetor connections are made. When the motor leaves this line by monorail and is lowered into the chassis, little remains to be done to the motor except to attach the exhaust pipe and mufflers, and to connect the clutch pedal. Brake connections are made and steering gears, which are stored near the line, go into place and are connected to the drag links.

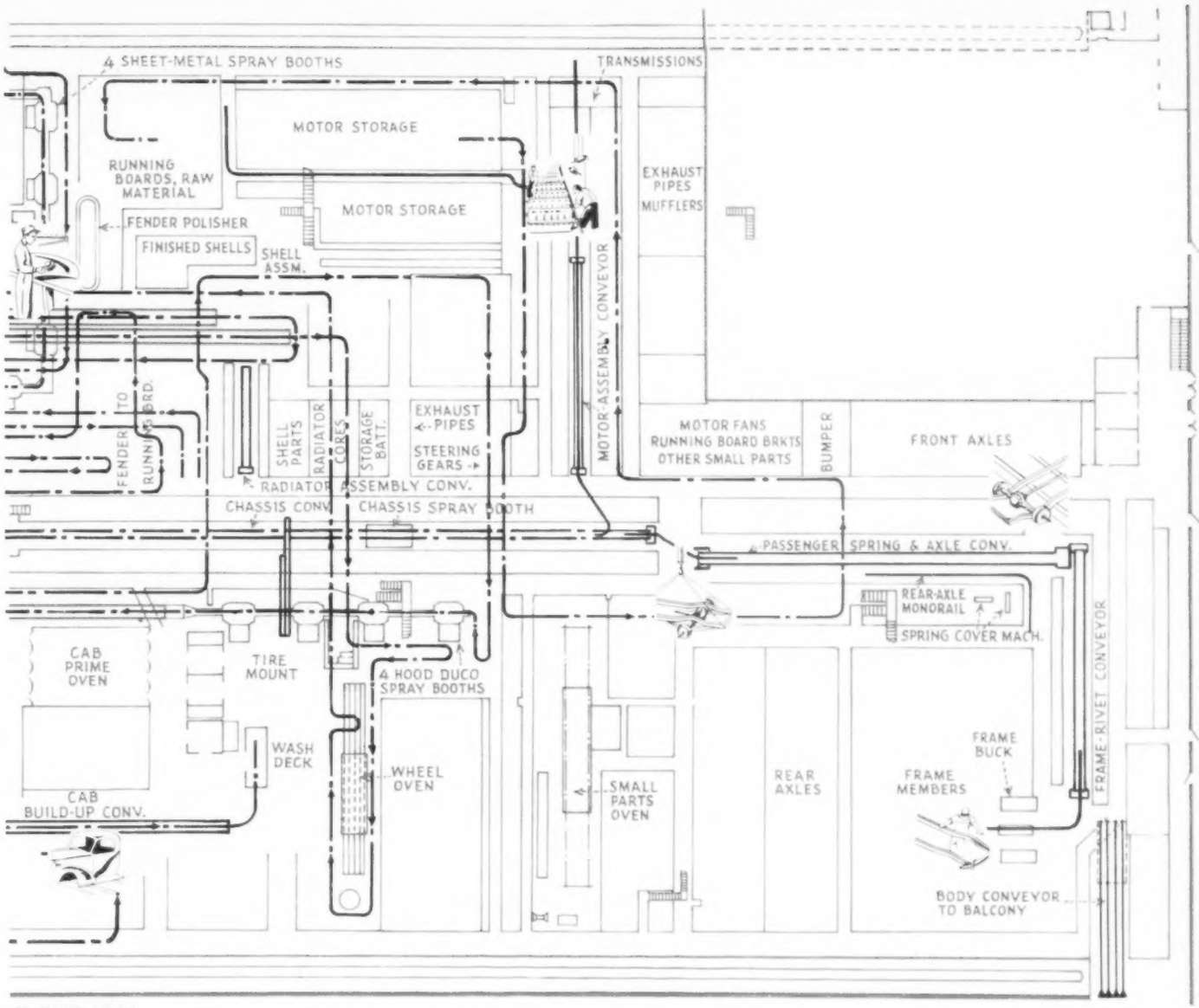
Then the chassis goes through the spray booth where any places that may have been scratched or marred, receive a coat of quick drying enamel. Storage batteries come into the line here and after them the radiator shells, which contain the radiator cores. These units are assembled on a conveyor line 40 ft. long.

Sheet Metal Finishing

Sheet metal parts, such as radiator shells and fenders are received from other plants in carload lots. These are in the rough, protected against rust by an oil coating. They first go through a cleaning process to prepare them for the finish coats or, as in case of radiator shells, for further assembly before receiving the radiator core. The cleaning or washing system parallels the bonderizing and enameling departments.

The assembly of radiator shells makes an interesting welding job. With 44 spot welds made progressively in a hydromatic welder. This machine is one of the latest available for this class of work. In addition, numerous small parts are welded with the semi-portable welders shown, these resembling the later developments of portable riveters, which also play a part in assembly. The completed radiators move on the conveyor automatically when the first radiator contacts a lever.

Welded into sub-assemblies, the radiator shells join the fenders and similar parts that must be finished in black or colors, to suit the modern trend in cars. The fenders, however, first go to the bonderizing sprays which with the drying ovens, make a unit about 200 ft. long. The bonderite treatment puts the metal in a condition where the enamel is a much more effective protection against corrosion than before. Bonderite of itself does not prevent rust.



AT BALTIMORE

Adjoining the bonderizing department is equipment for applying enamel to approximately 700 parts, large and small, that require this protection. All parts are dipped in black enamel for the first coat. This is done automatically by a timed conveyor which leaves just the amount of enamel desired. The thickness of this coat is checked periodically. From here the parts pass into the heater, or drying room, for baking. These drying rooms are kept at proper temperature and above atmospheric pressure so that no dust can enter if doors are opened.

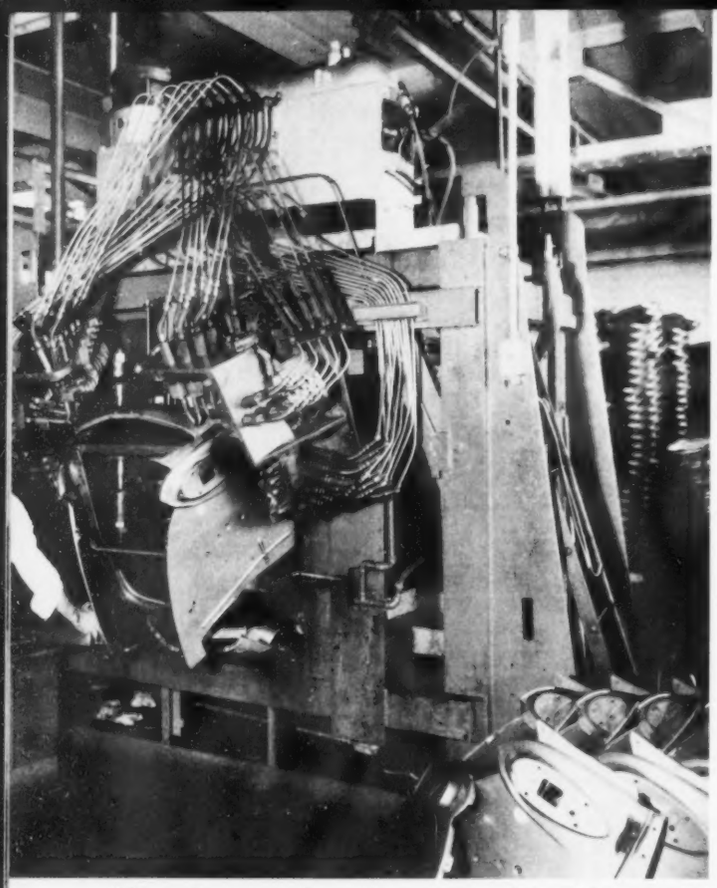
For cars that are finished in black, the parts receive a second coat of enamel in the adjoining oven, followed by another bake, as part of the finishing system. At the end of the heater room is a fire protection system consisting of a large bank of steel bottles containing Lux CO_2, under pressure. In both baking ovens are thermostatic controls that operate automatically when the temperature reaches the danger point. When this occurs, because of fire which seems bound to occur at times, the valves are opened automatically and flood the baking chambers with gas which smothers the flames.

Hoods and wheels have a dip tank of their own for the priming coat, as may be seen on the plan. They are also dried while on the conveyor, in the oven at the right. Radiator shells, hoods, wheels and fenders that are to be finished in colors, leave the dip enamel room after the first coat and go on a monorail conveyor. This conveyor passes through the four spray booths shown near the upper center of the plan and then pass to the left through the drying oven and back again toward the general assembly line in the center of the plant.

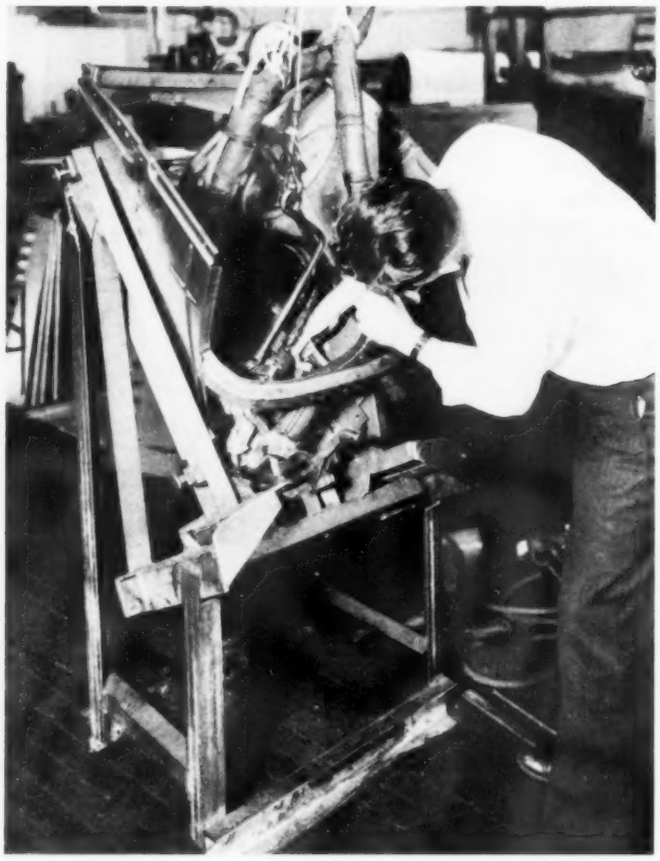
In front of spray booths is the fender polishing unit. This carries substantial forms on which the fenders rest while they are polished after they come from the conveyor line. A little polishing compound is put on with a brush, and a special power driven lambs wool wheel is used to give the desired finish.

Here again the telautograph plays its part in keeping the different colors in order as the fenders go back on the monorail that carries them to the conveyor line, in the proper sequence.

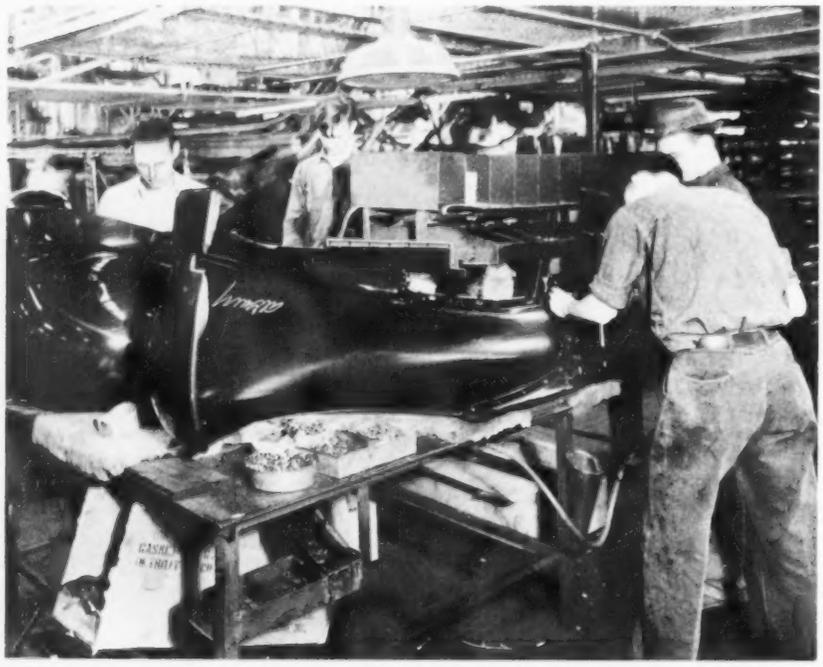
These monorail conveyors however give some flexibility by storing a certain number of parts which can stay on the conveyor until needed. The assemblers of front fender and running board units however must maintain the proper sequence of color, so as to have the right parts ready for the chassis when it comes. Blue radiator shell chassis must have blue fenders and be ready for the blue body that will come down when it



The various parts that make up the radiator shell are welded in the latest design of progressive hydraulic welder, which makes 44 welds in rapid succession



A portable welder puts the finishing touches on the radiator shell. The fixture makes it easy to locate the additional parts in proper position in the hood proper



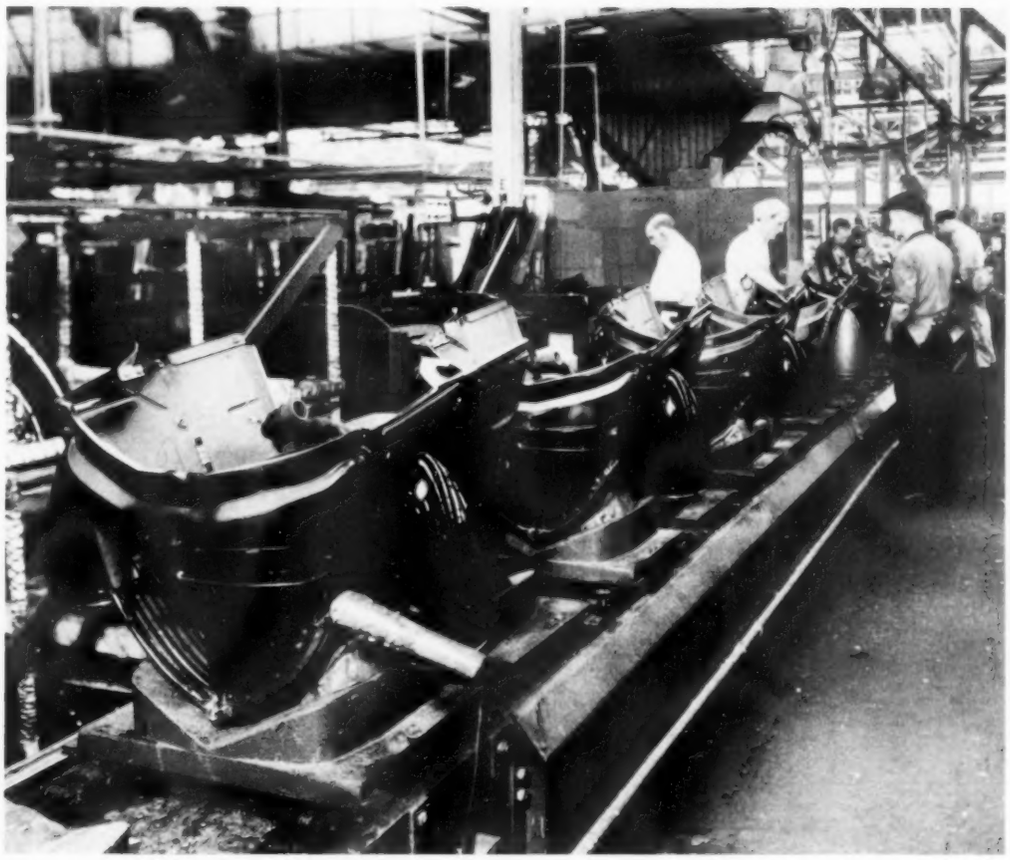
Fenders are assembled in pairs on suitable benches beside the main assembly line. Bolts, nuts and screws are kept in bins convenient for the men. Air nut drives are used

comes in place under the body drop.

Fender and running board assemblies are made near the chassis conveyor line and are placed on the chassis by hand when it reaches that point. They are built in pairs, right and left, and are fastened to the frame before the front wheels are bolted on.

Wheels are dropped each side of the conveyor line from an escalator that spans the assembly line. All the wheels first go to the tire-mounting machine, which is amazingly efficient. Drivers who have struggled to mount tires on the road, or even in the garage, will be impressed by the ease with which these tires go into place on the drop rims.

Here again the sequence is extremely important as five wheels of the right color and striping must be in the tire chute at the right time. For the two rear wheels must go on just after the chassis leaves the spray booth while the other three wheels, the fronts and the spare, are laid on the tail end of the chassis. Then after the fenders are put in place the front wheels are mounted and the spare put inside the trunk after the body comes down. And they must all match each other and the radiator shell as well as the hood.



After the radiator shells have been properly finished with enamel or other coating, they have the radiator cone mounted and the lamps attached, ready for final assembly. Each shell rests on padded blocks that carry it to the assembly line. The conveyor is stopped automatically when the lamp on the first shell contacts the arm in front of it

Dispatching, or control of the flow of material, is absolutely necessary to insure a steady flow of product. With two styles of chassis, Master and Master De Luxe, and with numerous body styles and colors, it requires accurate dispatching to assure that the proper parts meet the right chassis as it moves down the center of the shop.

Matching Chassis, Body and Wheels

Control begins with the delivery of the bodies from the Fisher body plant that is only separated by a wall from the assembly plant itself. Bodies come in at the lower right hand corner of the plant and go up a ramp to the second floor. Each body is mounted on a felt-covered dolly or truck as it comes from the body plant. After the body has been lowered to the assembly line, the dolly goes down a ramp into the body plant next door.

As each body leaves the body plant a brief, symbolized description of it is "telautographed" to every department of the assembly plant which is affected by body style or color. This only affects the chassis as to whether it is a Master De Luxe, with its Dubonnet knee action, or a Master, with regular semi-elliptical springs and front axle. Fenders, hoods, lamps and wheels must be ready to match the body when it is lowered to the chassis from the second story.

The sequence of the styles and colors of the bodies in the bank of from 50 to 100 that wait to be dropped on the proper chassis, determine the order in which the variables mentioned go through the finishing lines. The sequence of these telautograph orders guide each department head in routing his work. Without a system of this sort smoothly flowing sub-assembly lines would be much more difficult, if not impossible.

Dropping the Body

The chassis has now reached the body drop, or opening from the gallery above, where the body is lowered into place. Just previous to this a resilient pad has been placed on the frame at every body-bolt hole. These pads have holes for the body bolts and are held in place by strips of adhesive to make a cushion between body and frame and prevent squeaks that are so annoying to the user.

A pit beneath the conveyor makes it easy to tighten the body bolts that have been put in place as soon as the body is positioned on the frame.

Hood parts come in pairs from the dipping and baking ovens, on a long monorail that brings them overhead, across the central assembly line and through the Duco spray booths shown below the chassis conveyor. Here are four booths, each of which can handle a different color if desired. From here they go to the hood assembly, shown near the hood polishing conveyor.

Hand riveters and air-operated nut wrenches play a part in this work. Here, as in other places in the shop, the air-operated tool is a favorite on parts for which they are adapted. The men like them because of their light weight and convenience. And, while it is generally conceded that air is more expensive than electric current as a source of power, the low maintenance cost is said to offset this. One of the interesting air tools is the Keller ratchet wrench, which enables the workman to get at inaccessible places and so speed assembly. Although shown in use on motor assembly it is equally valuable on other work.

Here too the chromium-plated horizontal side strips that grace this year's hood are put in place. They are held by special fasteners which do not show from the outside in a very ingenious way. This is one of the interesting details that have been work-

ed out to give pleasing ornamental effect without excessive cost.

Near here is the hood finishing department where they are polished on a conveyor. The hoods have previously been dipped and sprayed where color is wanted, on the other side of the main assembly track. A monorail conveyor brings them over the assembly line to the finishers in their proper sequence.

They are placed on suitable supports for polishing, a paste is used with a lambs wool polishing wheel, and as a final touch they go through a dryer. A recent improvement in this department is the introduction of an exhaust-hood system in connection with this polishing operation. The exhaust hoods, placed over the hoods being polished, remove whatever dust may arise and so eliminate all possible silicosis affection.

As the nearly completed car moves down the line on the floor conveyor, gasoline is put in the tank and water in the radiator. Before it reaches the end of the line, an air hose on the filling spout puts pressure on the gas tank and forces fuel up into the carburetor. With the hood in place a driver steps inside, touches the starter, the motor fires and the car rolls off the assembly line.

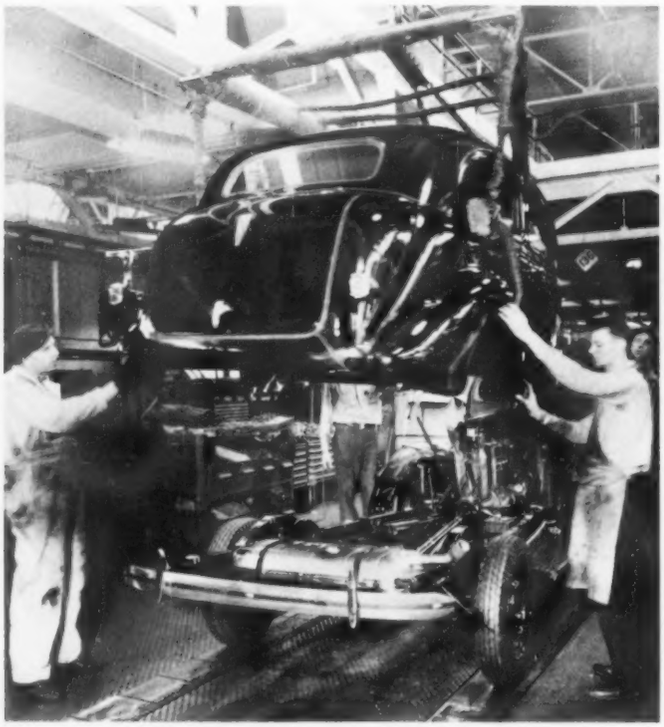
Straight ahead of the assembly conveyor is a door leading to the building where all tuning up and servicing is done. Just outside the door is a series of "bumps" on which the wheels jump up and down on their way out. These give the knee actions and shock absorbers plenty of vibration and insure the oil in them being thoroughly distributed.

New car conditioning includes a track test which presents different road conditions and the final adjustments and tuning up that was formerly given by the dealers or distributors. This system of giving the final preparations for use at the factory, insures a uniformity in new cars that was not attainable under the old method of having each dealer give final servicing before delivery to the customer.

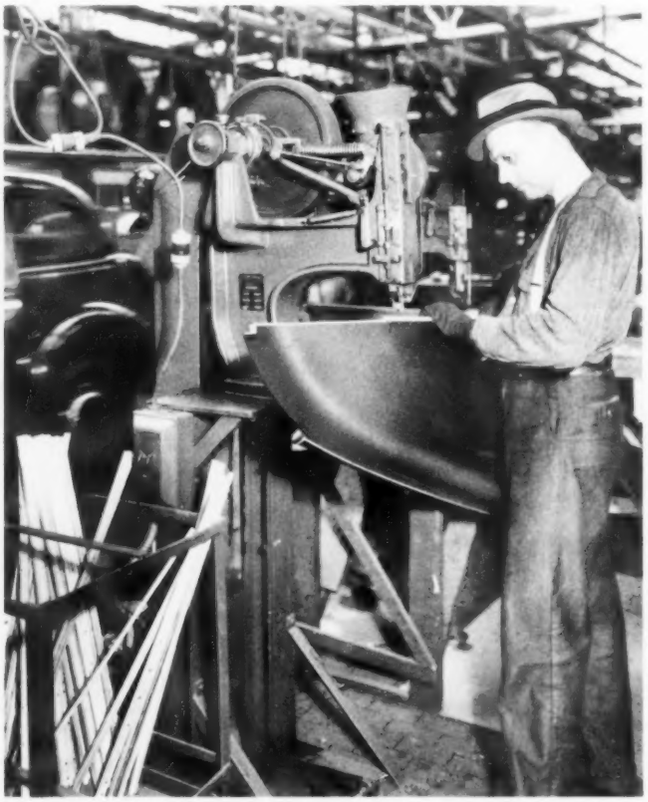
Putting Trucks Together

One class of commercial cars, with panel or sedan bodies, is assembled on the passenger conveyor with the regular cars. All the other trucks are assembled in the space below the passenger car line. Larger commercial vehicles have different and heavier frames, according to their size and capacity. Many of these frames have special reinforcements on the side, or in front, to accommodate special auxiliary apparatus. To some extent at least, this section is sort of a jobbing shop where individual requirements as to frames and bodies can be handled promptly.

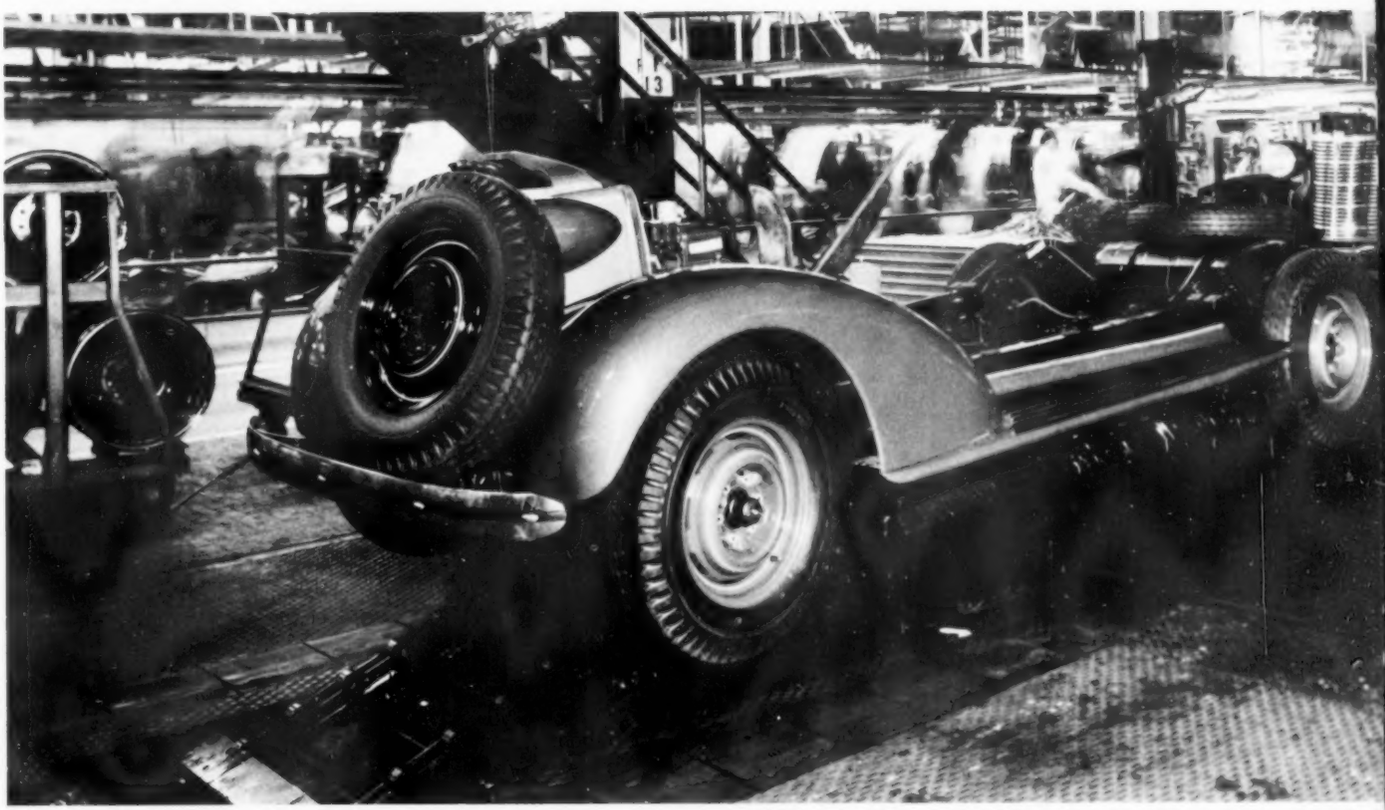
This department is complete in itself, as can be seen from the plan view. It has its own spray booths, its own heating ovens for small parts and for wheels, its own storage for parts, cab-building conveyor and other sections. The frames are built up according to specifications, on the frame buck shown. Then axles and springs are assembled on the adjoining conveyor, from which the monorail carries it to the chassis conveyor. This passes through a spray booth in much the same way as the passenger chassis, and goes on to receive the body, running boards and other parts. The truck bodies come from the Indianapolis plant. Truck bodies take up so much more room than passenger car bodies that they must be handled dif ferently. The stake bodies have a special spray booth.



When the chassis reaches the body drop it is practically complete. Fenders and wheels must match the body that is lowered from above. Hoods go on farther down the line

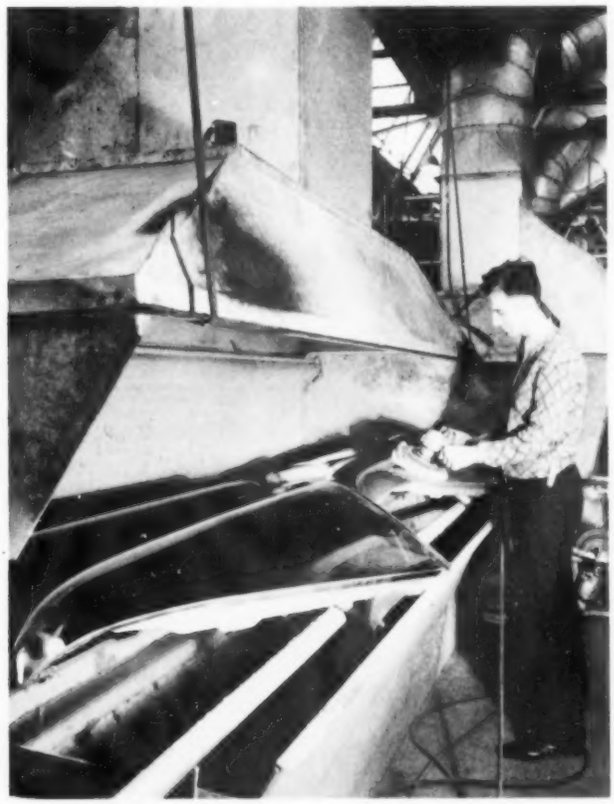


The long central hinge is riveted on the hood. The assembly of the two parts of the hood, and the putting of the decorations on the side panels, include some interesting operations



After front fenders, running boards and wheels have been put on the chassis, it leaves the "high" conveyor and the wheels contact the floor level conveyor that carries it until it is run off under its own power. The tire on the front bumper is the "spare" for the car just ahead

Air tools are popular with the assemblers because of the light weight. Here an air-operated rachet drill makes it easy to tighten nuts in an inaccessible place



Exhaust hoods over the hood polishing racks are the latest in the endeavor to create comfortable and safe working conditions. Slow moving conveyors give time for a good job.

BRANCH PLANT FOR BODIES

A BRANCH, body assembly plant of the Fisher Body Division adjoins the Chevrolet plant in Baltimore, with only a wall between. Body parts, such as floors, roofs, side panels and doors, come from the Detroit plant where they are stamped and in some cases more or less assembled, as in the case of doors. The advantages of this method are obvious when the cost of transportation is considered. For where five complete bodies can be put in a box car by careful packing, parts for about 100 bodies can be shipped in this way.

This method means that the body assembling plant must be equipped with welding machines for joining the parts that go to make up the complete body. Equipment of this kind duplicates that used in the main plants, some of the welders being illustrated herewith. The parts are unloaded on platforms beside the freight tracks and are either put on conveyors or taken by power lift trucks to their proper places. They meet at the welding machines where they are joined together by the most modern methods.

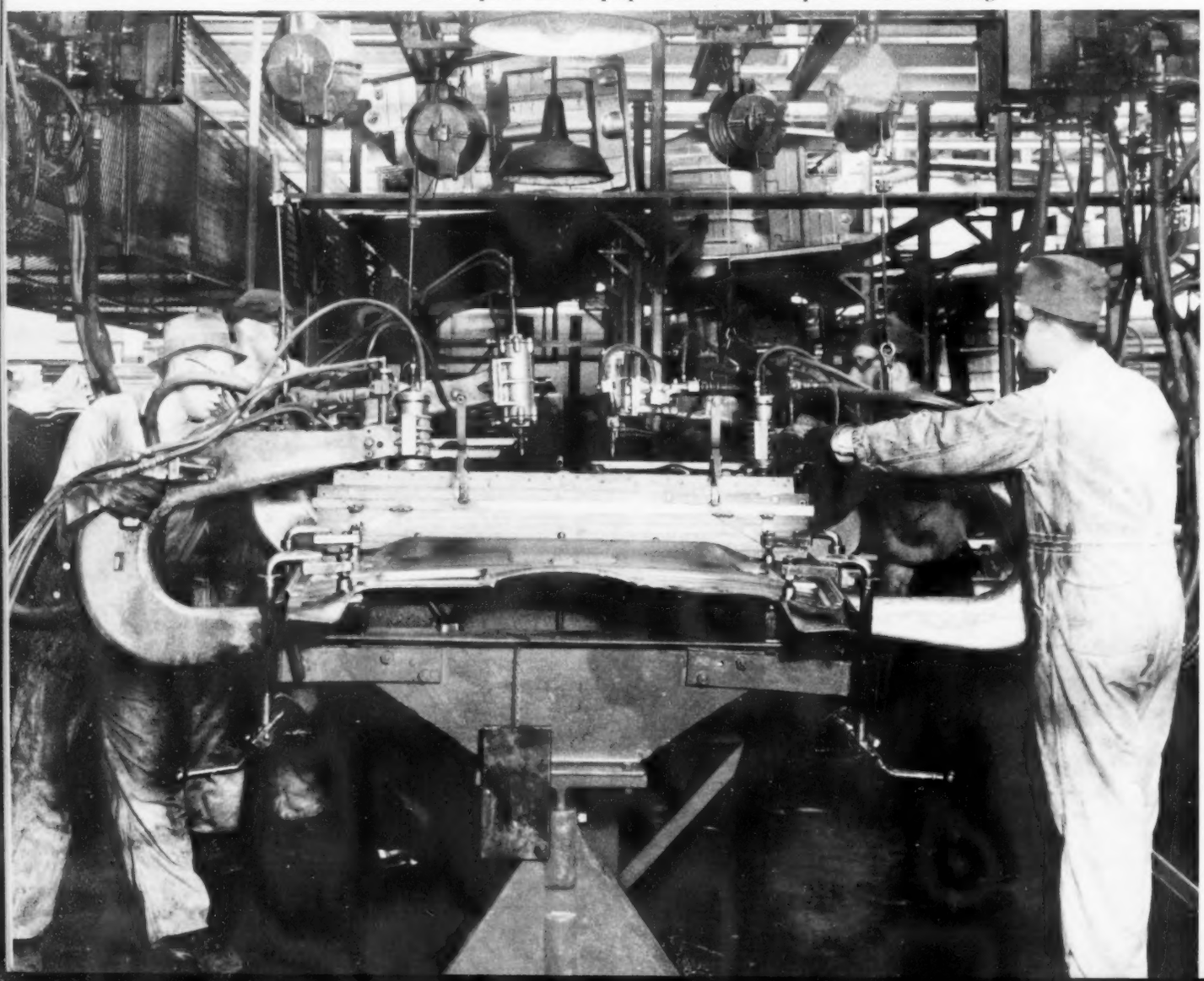
Both spot and seam welding is used in joining the various parts, and only those who are familiar with these processes can realize or appreciate the success and economy of these methods. The flash of the seam welds has to be shaved to secure the smooth surfaces necessary, and there is usually a small amount of filling to smooth out a few contours to please the eye. This is done with a soft solder; expert workmen flow this on in just the right quantity. The speed with which this is done is amazing, and the result of their skill requires but a minimum of smoothing to be ready for the spray that deposits the various coats of lacquer that give the completed bodies their final finish.

Spraying, baking and polishing are all done with the modern equipment available. Before leaving the plant for the Chevrolet assembly next door, they pass under a double row of lamps arranged so as to give a brilliant illumination that shows up any defects to the inspectors.

One of the first body assemblies is the welding of the steel floor units into one piece: This is done with four portable spot welders. With the parts positioned on the frame and clamped in place, the welding is quickly done.

Operations on windshield frame parts illustrate modern welding in a striking manner. More unit assembly welding is used to join the rear side panels to the lower part of the back. This welding is done in a pair of machines, the mating machine welding the other side. The upper electrodes are raised to insert the sheets,

Four portable spot welders make the steel body floor into one solid unit. The welding fixture locates the various pieces in their proper relation and clamps them before welding

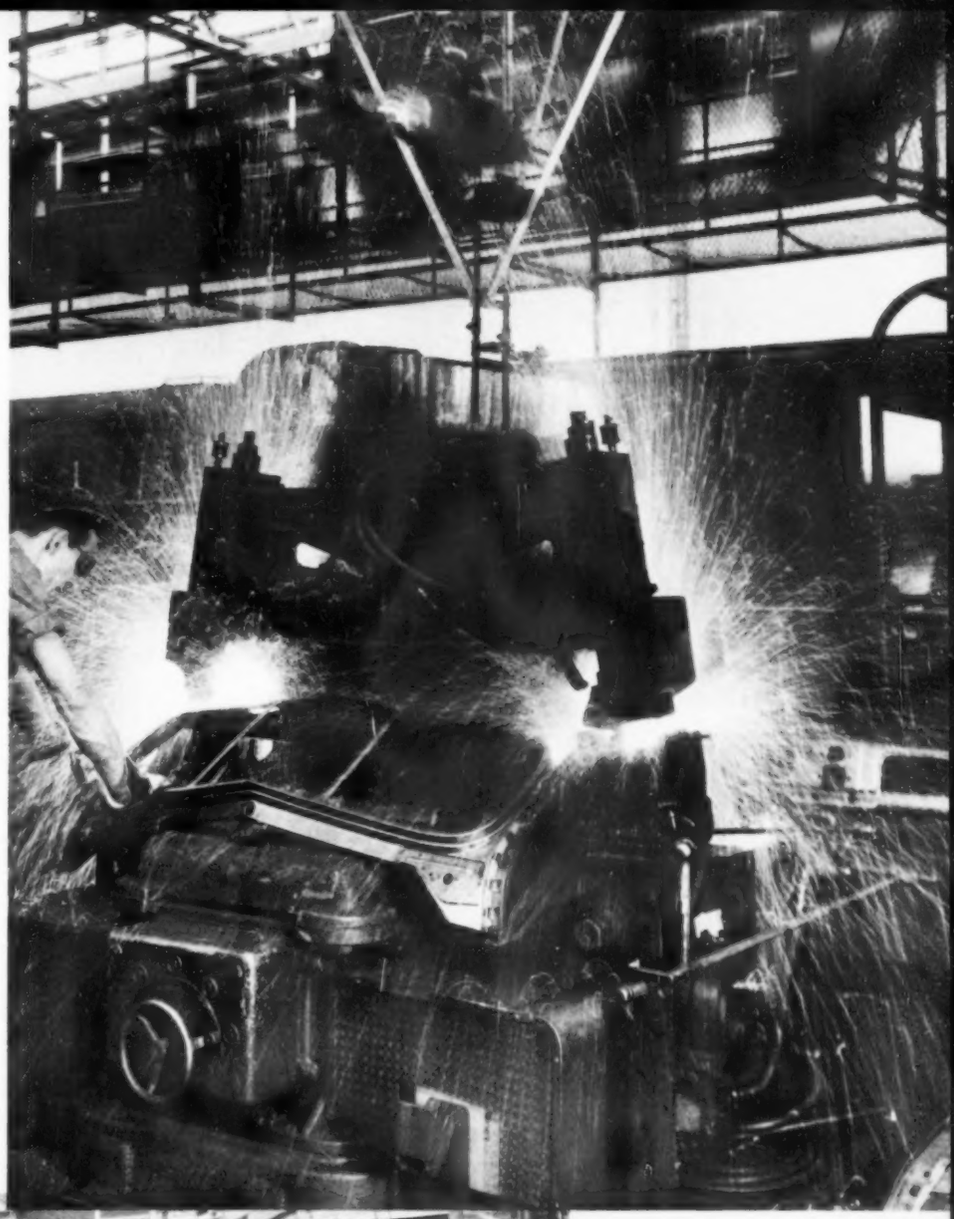


then lowered into contact for welding.

Upper part of fixture for welding reinforcements to the roof stamping is raised to insert the top and is then lowered and clamped to hold it firmly in position.

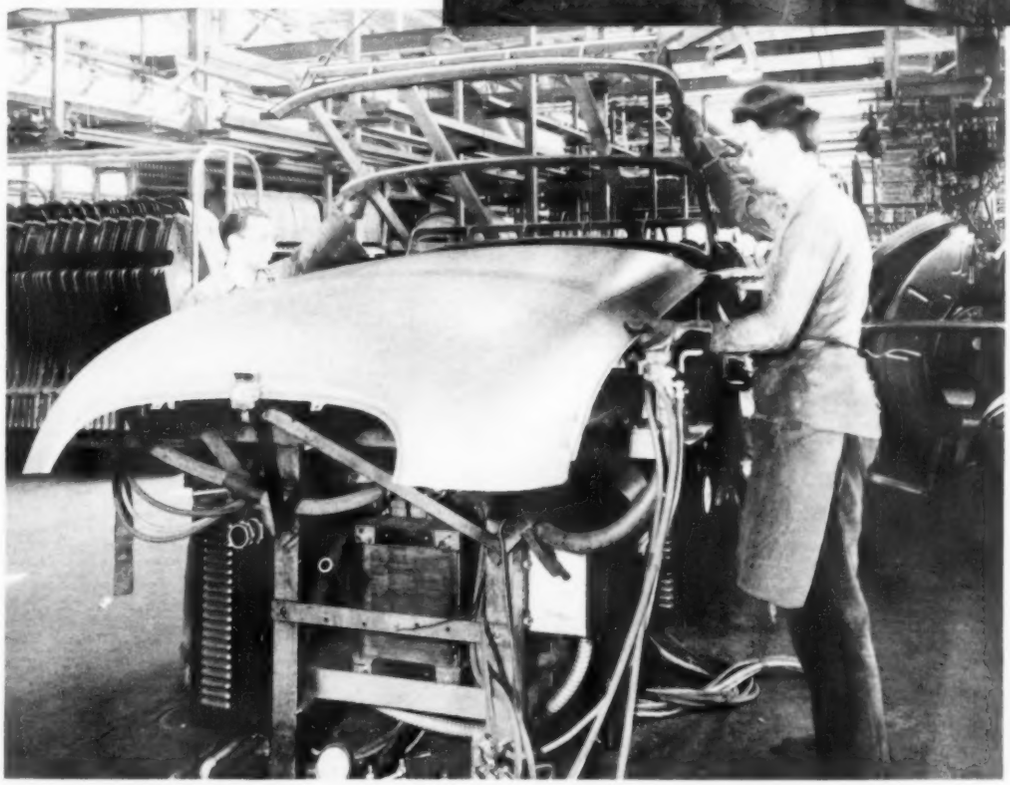
When the component parts are ready they are all placed in the body fixture, and the different sections are welded into a complete whole. The fixtures, or machines, hold the parts firmly by air clamps, and the welding is done almost instantly.

In the meantime doors and other parts go down the assembly line. The window regulators and the locks and hinges are put in place. Doors are hung on the bodies on the parallel conveyor line and the bodies go on their way to completion. Powerful lamps throw a flood of light on the bodies as they go down the line giving ample illumination both for working and inspection.



Windshield parts and uprights are welded rapidly in this special machine. The strength of this unit contributes to the safety of the all-steel body

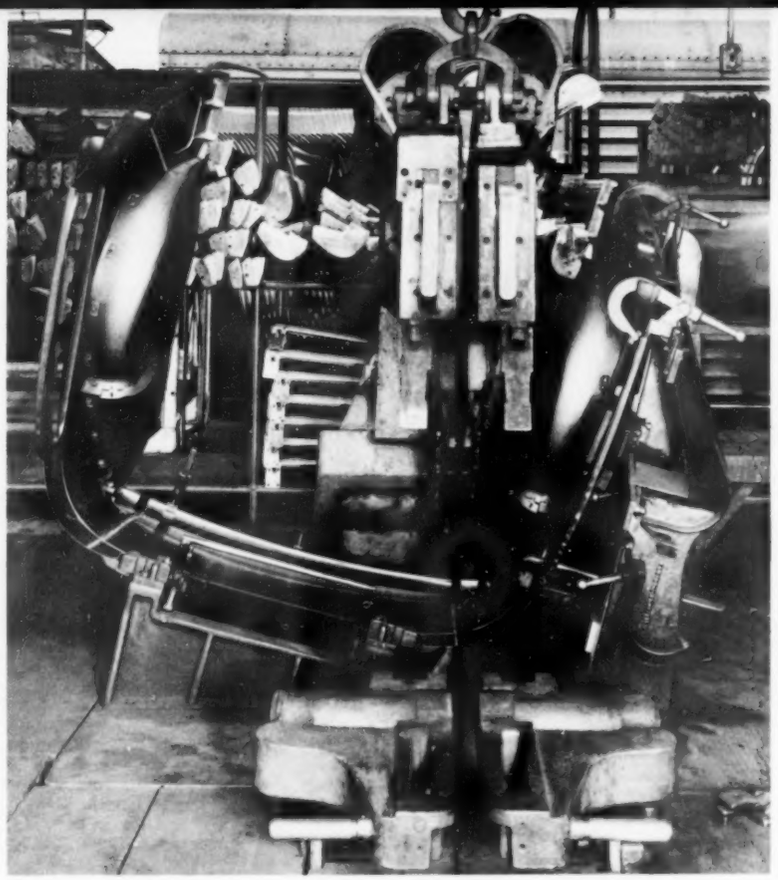
Reinforcements are put in place while the one-piece steel top is held in a welding fixture designed so as to make it easy to handle the work and locate it

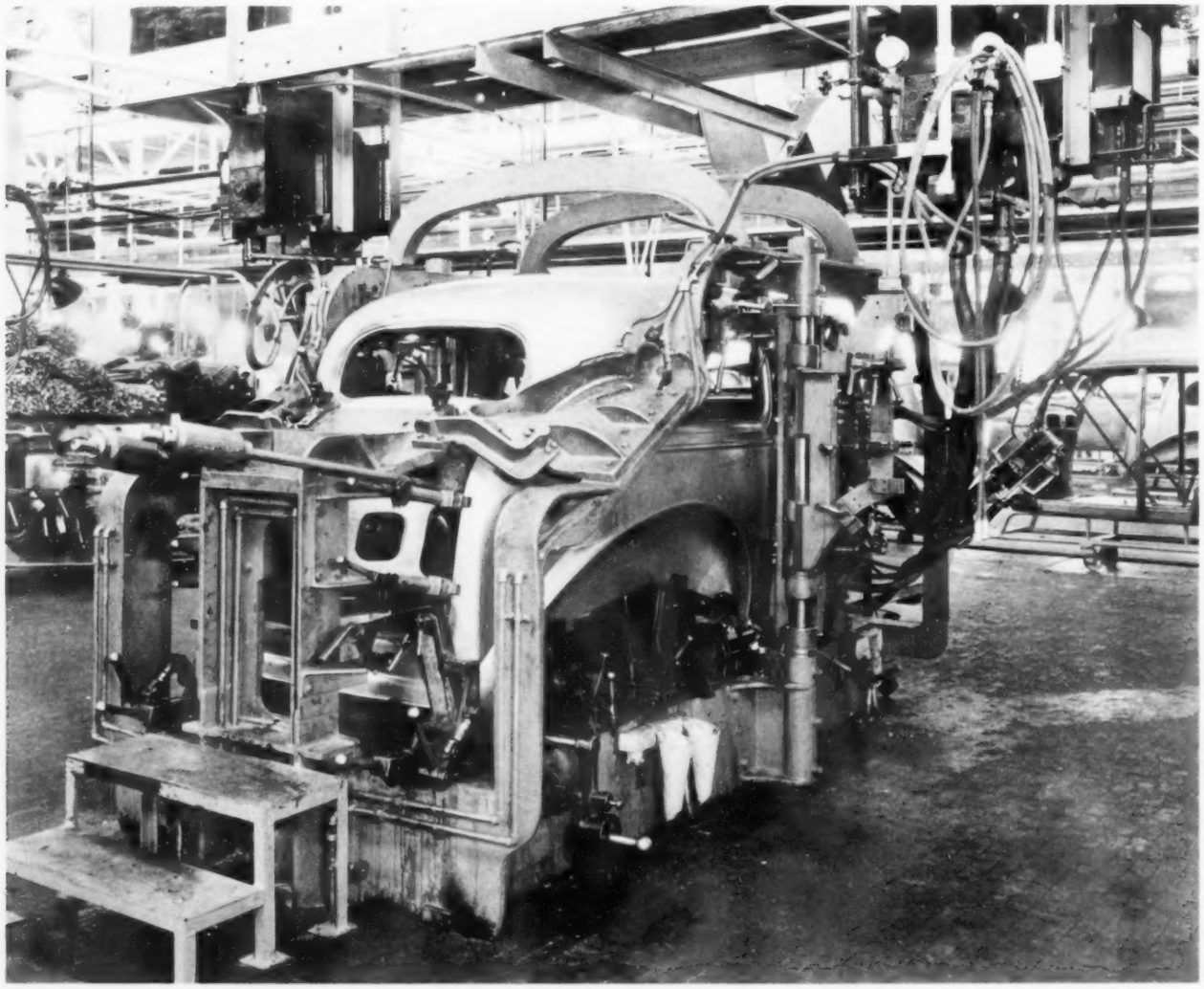


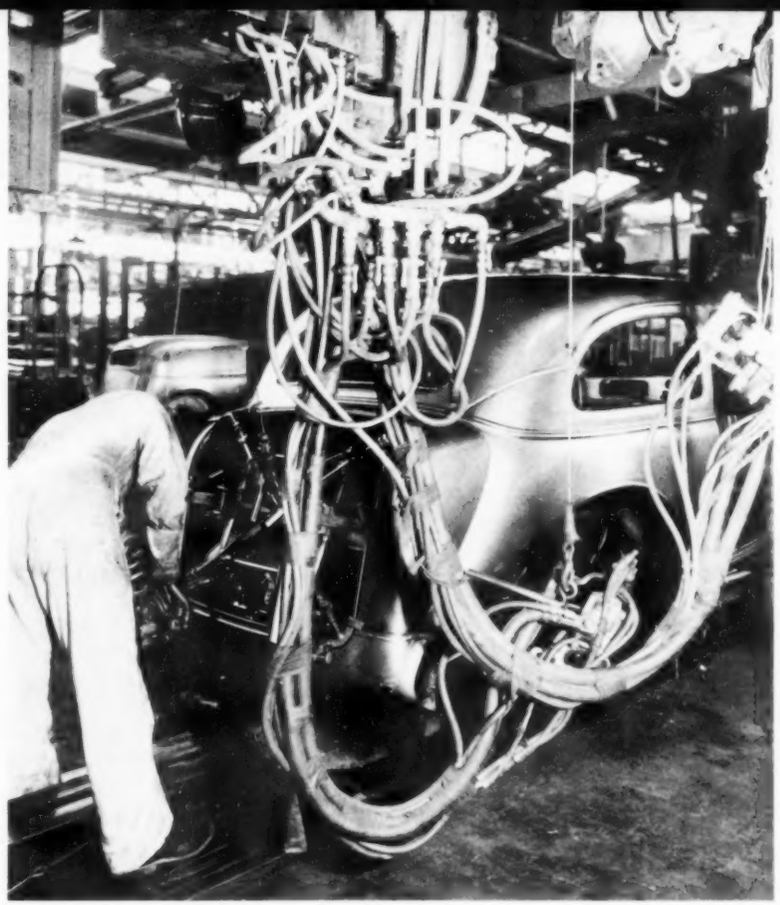
One of the many welding details is in putting reinforcements in the opening for the door of the trunk. Here a frame clamps the opening at various points and holds the sheets firmly while the welding is being done. Portable spot welders are used, carrying both power cables and air hose for actuating the clamps.

Completed bodies are then sprayed and baked in the usual manner and, after upholstering, come down the final conveyor line for inspection. Here again flood lights are used to enable any defects in finish to be readily seen. The advantages of height can be seen by noting that the 7 ft. 5 in. man can reach the roof and can see the whole surface.

From this conveyor the dollies carrying the bodies go through an open doorway into the Chevrolet section of the plant. Here conveyors carry the bodies up to the gallery over the chassis assembly line, where each body meets the proper parts to complete the kind of car called for by the schedule.







Another special welder joins one side panel to the rear quarter. A corresponding mating machine previously welds the other side panel in place

Here the various subassemblies are welded into a complete body. In addition to welding electrodes in the machine itself, portable spot welders are conveniently located to make other welds where needed

Still another welding job reinforces the trunk door opening. A frame that fits into the opening holds everything in position so as to insure a good door fit

Final inspection of bodies before going to the ramp in the assembly plant. Spot lights facilitate inspection. Both tall and short men are useful in the final inspection of bodies before they go to the car assembly plant

EXPORT

KNOCKED DOWN FOR SEA SHIPMENT

EFFICIENCY in boxing units for export is measured by the amount of free air or "cubic" in the cases. At the Bloomfield, New Jersey, Chevrolet plant this waste space has been scientifically reduced to a minimum. This is the plant from which passenger cars and trucks in about equal numbers are shipped C.K.D. (completely knocked down). Additional exports are shipped from the Tarrytown plant in a semi-knocked down condition.

No manufacturing whatever is done at the Bloomfield plant, but there are seventeen short assembly lines on which the parts for export cars and trucks are assembled and boxed. Adjacent to each of these lines are series of bins in which the component parts are stored. Since there are 1200 different combinations of packs for export, an air-tight inspection and control system has had to be devised.

Parts arrive by freight from the various manufacturing plants of Chevrolet, from the General Motors Parts plants that supply Chevrolet parts and from outside suppliers. An occasional small shipment arrives by express. Each shipment is blind checked as it arrives and listed on a receiving slip. One sample part from each shipment is checked according to the engineering specifications and to an approved sample that is mounted on a sample board.

Each copy of the receiving record is signed by the receiving inspector, and the receiving department then accumulates the various forms and sends them to the materials and accounting departments for check against the invoices. The same type of blind check is made on outgoing cases, but in this instance the assembled forms are sent to the traffic department for final check.

Counts of parts are made by hand when the lot is less than 200. Above that a scale count is made. Many ingenious jigs, most of them made of wood, have been designed and built in the plant to do a combination job of counting and inspecting. A jig will have the requisite number of holes, nests, pins or slots to accommodate the number of similar parts required for an individual shipment, and is arranged so that only the parts for which it is designed will go into it. Since many of the export cars have to be arranged for right-hand instead of left-hand drive, most of the jigs are designed so that they will take parts for right-hand drive when placed right-side-up and the parts for left-hand drive cars when turned upside-down. Metal jigs for the heavier parts are mounted on trunnions in their frames for the same purpose. The trunnion is locked in position and can only be released by means of a key which the foreman carries. Counting jigs for passenger car, commercial car and truck parts are painted in different colors to distinguish them.

As the operator fills a jig it is checked by a checker who marks it by running a red or yellow crayon across the parts. Cases in which the units are to be packed are marked alternately red and yellow as they come down

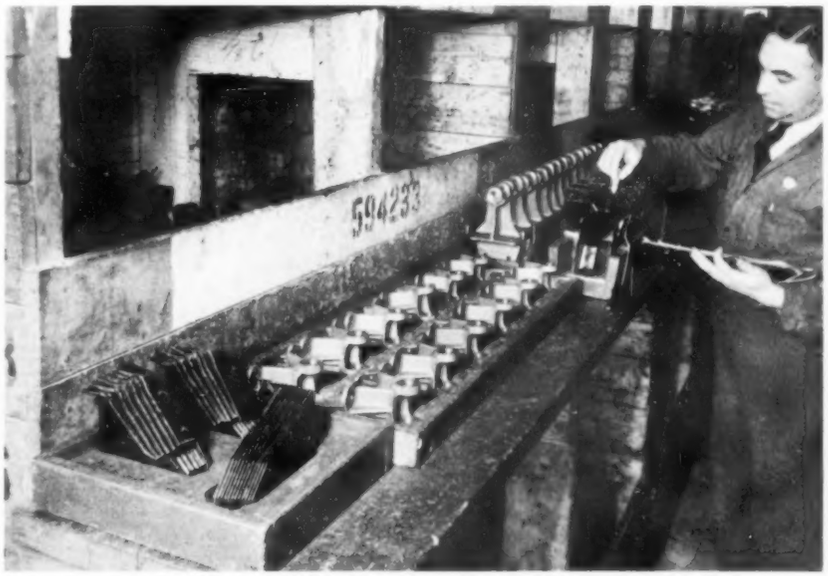
the line as an insurance against getting two lots of the same piece in one case. In addition to the regular checkers, there are eight roving recheckers who are constantly circulating around the plant looking for errors. If they find mistakes, the assumption is that the system is at fault or else has broken down in a special instance rather than that the operator has not done his part. The plant operates on the theory that every man in it wants to do a good job and that he should be given every facility to make that possible.

Various types of simple checking gages have been designed and made in this plant. For instance, each of the gages used to check the pitch of speedometer drive worms is made in the shape of a figure corresponding to the number of threads per inch. This makes it easy to pick up quickly the gage you are looking for.

Inspectors take nothing for granted. Every leaf spring is checked by gage to be sure it is correct, and such parts as lamps that come packed in their own cartons are opened and inspected to be sure that they are what they are supposed to be. Close inspection is doubly important in a plant of this sort because errors that would soon be caught on the assembly line in a domestic plant do not show up until the shipment reaches its destination which might be a long way from the manufacturing plant, and are then very difficult to rectify.

One counting jig that is used extensively for small parts that have to be assembled in relatively large numbers is a galvanized iron square tray perhaps 15 in. square with three sides about 3 in. high and an open front. The bottom is divided into 12 rectangles by raised ribs that are put in by means of a hand punch and hammer in the jig department. A special fixture devised by one of the jig makers simplifies this process materially. If 48 parts are needed for an assembly, it is a simple matter to put four of them in each of the twelve squares. Operator and checker can tell at a glance whether any square contains more or less than its required quota. As soon as the lot has been checked it is dumped into a bag and properly tagged.

Each of these tags, which are attached to all shipments, has a detach-

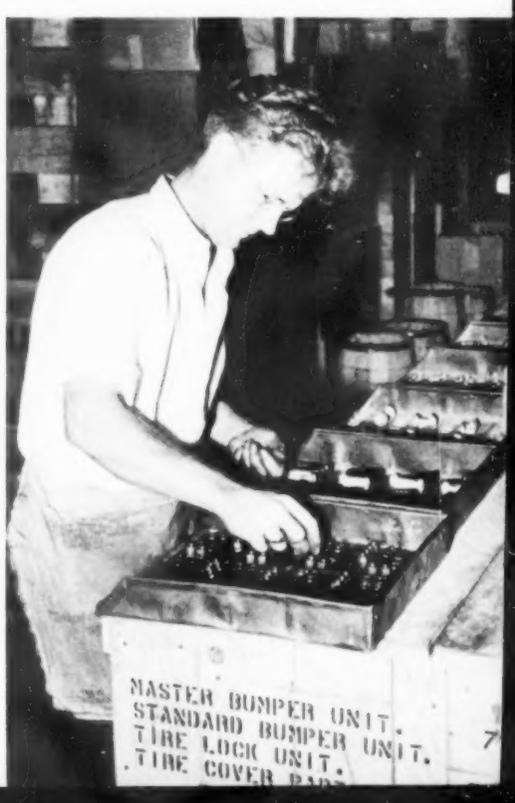


Parts are checked against a sample board so no doubt exists as to their identity

Count and kind of each part are inspected by a checker before he gives the shipment his O.K.

A trunnion-mounted jig aids in assembling and counting chassis parts. It may be inverted to accommodate parts for cars of opposite drive

Counting jigs made of sheet metal have raised ribs to form suitable compartments for the parts



able gummed duplicate which is removed after the unit is in the case and stuck to the office copy of the packing slip. This system has been found to be very effective in reducing the number of complaints of shortages at the foreign assembly plant.

All sorts of ingenious methods of reducing the cubic displacement of parts have been devised. Seat springs, for instance, are baled twelve in a bale and compressed to about a sixth of the volume they would occupy in their normal state.

Engines are received in freight cars that carry 105 engines on special racks. They are picked up by an electric hoist and deposited on a special three-wheel truck, built at the Bloomfield plant, on which they are wheeled to the engine line. Several ingenious fixtures are in use on this line to assist in the inspection and in the simple operations that must be performed on the engine. The generator is mounted to save cubic space. To make sure that the clutch fork is on the correct side there is a gate farther along the line attached to a stop switch which it operates if a wrong mounting trips it. A stop indicates an error.

As the motor proceeds along the lines the paper plugs closing the spark-plug holes are removed, and the engine enters a fixture in which a predetermined amount of lubricating oil is squirted into each cylinder through the spark-plug hole. At the next station another fixture operates the starting motor and turns the engine over several times to spread the oil over the cylinder wall. After this the spark plugs are inserted and the engine goes to the shipping case. Here the valve cover is taken off and the valve rocker mechanism released to let all the valves seat and thereby seal the cylinders. Then the cover is replaced.

Shipping cases are received in panel form from several southern mills. They are made of 11/16-in. lumber and are lined with 60 kraft paper. Various systems of inside cleating support the various parts and the content is then covered with a sheet of Fibreen paper which is tarred to the lining paper. Another sheet of Fibreen paper is tarred again on top of the first one and the cover is then put on and nailed fast. Nail spacing is standardized. Over the cover a tar film is applied to seal the joints, and then another waterproof paper sheet is put on. The heavier cases are finally reinforced with metal strapping.

To get into the contents of a case water would have to work its way through four thicknesses of paper and tar; so far it has never done so.

One of the many means of gaining compactness is the compression of cushion springs to a sixth of their normal size

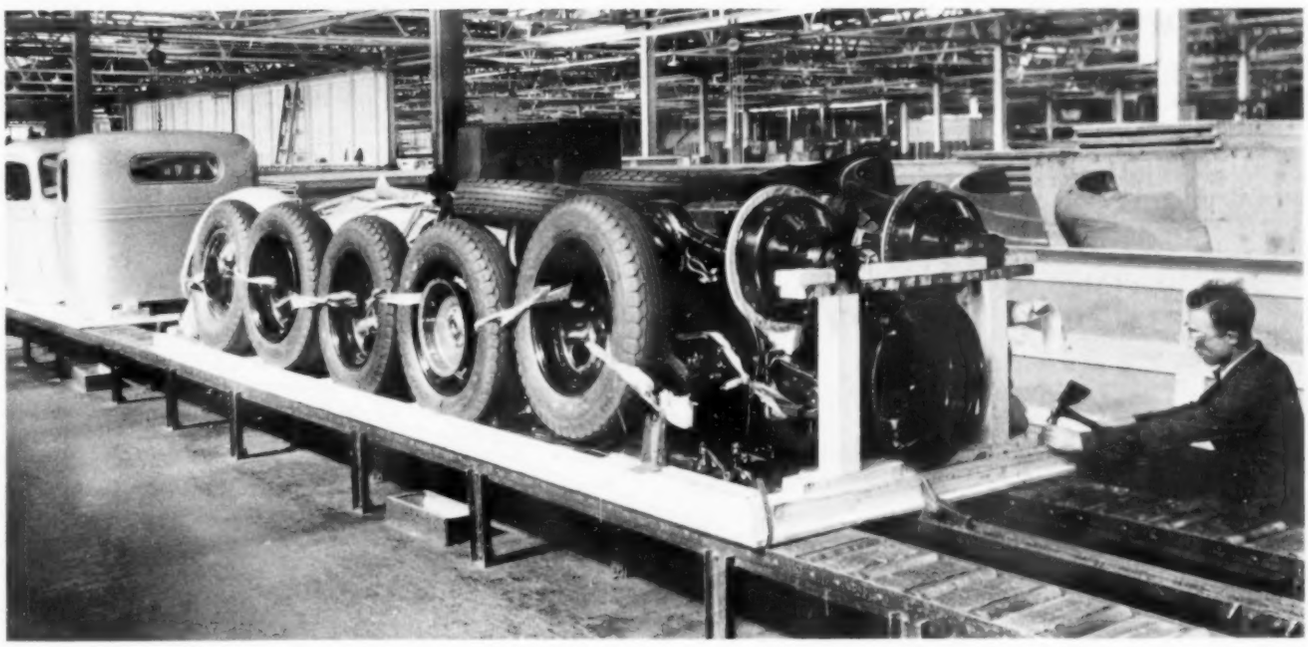
Pitch gages for speedometer drive worms are made in the form of numerals that indicate their pitch

COMPACT CRATING

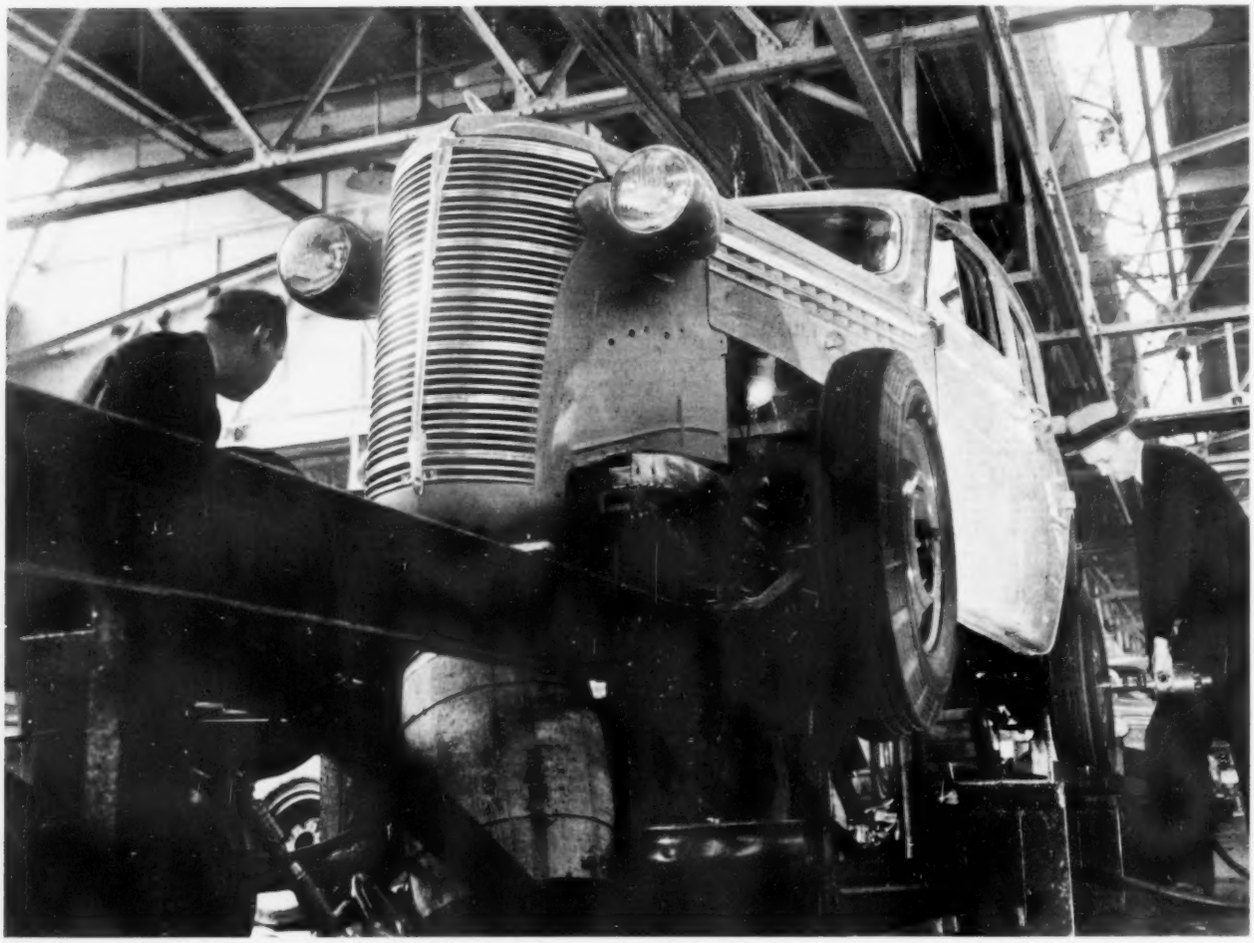
ALL Chevrolet cars and trucks for export which are not shipped completely knocked down are prepared for export at Tarrytown, New York, assembly plant. Out of a normal capacity of 140,000 cars a year at Tarrytown, about 27,000 are for export. The average daily production for export is 150 units, half of which are boxed and half shipped on wheels. Among countries to which Chevrolet cars are sent from Tarrytown are India, China, South Africa, Chile, Venezuela, the Philippines, Sweden and Egypt. Export operations on cars boxed for shipment are shown.

Passenger cars and trucks are boxed as they move down a roller conveyor line. Note the position of fenders for shipment

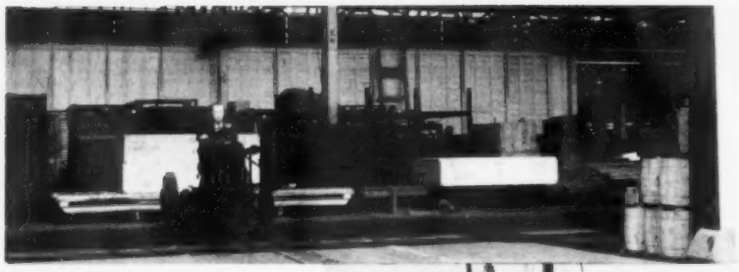
After being assembled, truck chassis and passenger cars are tested on a track outside the factory before starting down the line to be prepared for export



Two chassis of 157-inch wheelbase dual trucks are compactly boxed in a space 224 x 63 x 43 inches. Cloth is used to tie fast the wheels because taut rope might mar the paint surface. Cabs for the two trucks are boxed separately

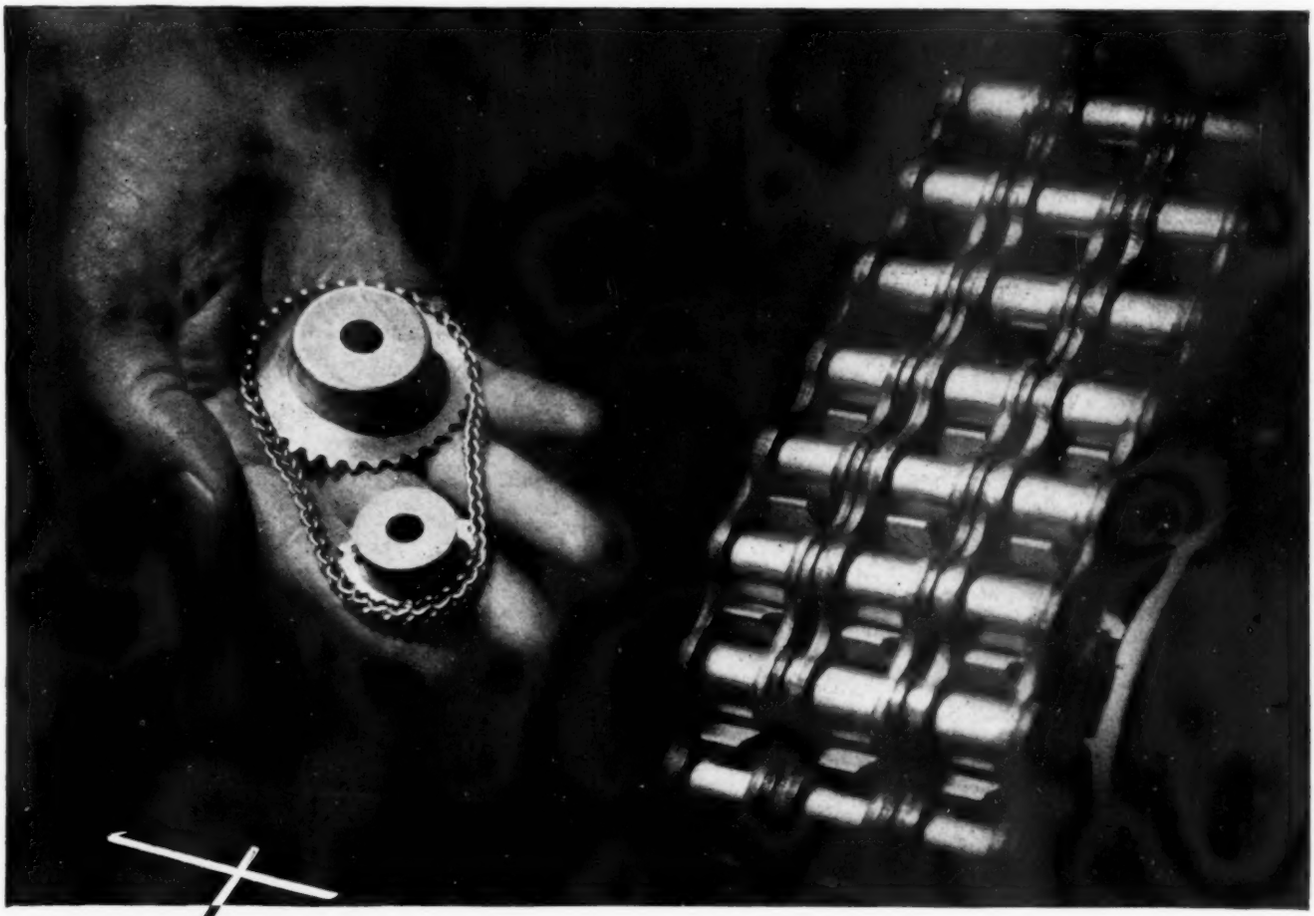


Wheels are removed at a "disassembly" station so that the car can be packaged for shipment in as small space as possible. Precautions are taken to see that engine parts do not rust en route



Packaged cars are pushed onto a dolly which is an extension of the roller conveyor. Running on rails at right angles to the conveyor, the dolly with its package is pulled by a gasoline tractor to the Hudson River dock outside the plant

A yard crane picks up a box containing two large truck chassis and transfers it to the dock or to a lighter which takes it to a New York pier or direct to an ocean freighter



from "flea" power to 100 horsepower

YES SIR, chain drives from "flea" power to one hundred horsepower and all from stock too. When you need chain drives in this range you know that if you buy from Boston Gear it will not be a matter of waiting days or weeks for delivery, because the chain and sprockets are in stock ready for your use. Seventy-seven pages of the new Boston Gear General Catalog #52 are devoted exclusively to these products. On these pages you will find your answer to chain and sprocket specifications, list prices, lubrication of chain drives, horsepower selection charts, and construction and list prices of chain cases. If you want one or more copies of our new General Catalog just let us know, we shall be glad to send you as many as you can use.

BOSTON GEARS

BOSTON GEAR WORKS, INC.

NORTH QUINCY, MASSACHUSETTS

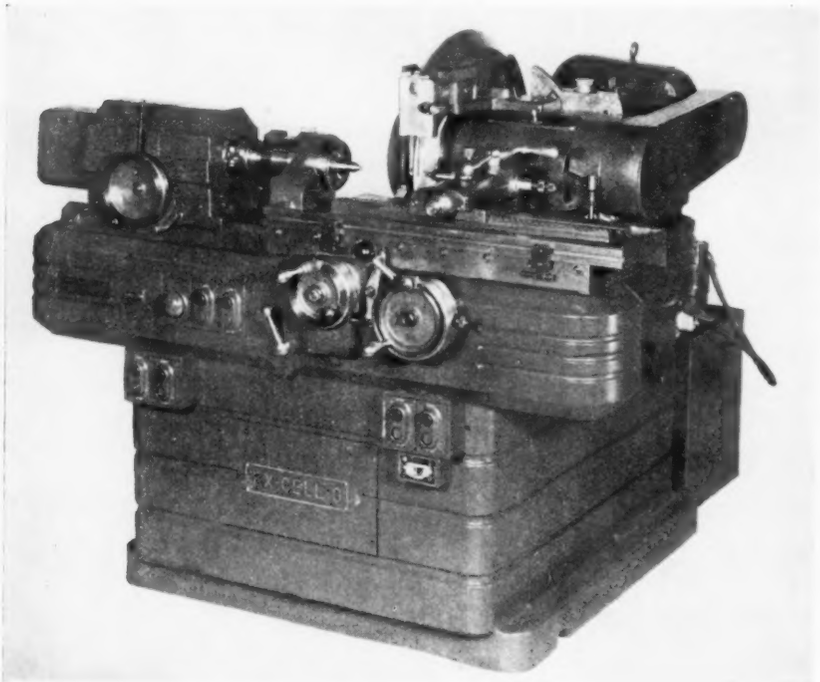
SHOP EQUIPMENT NEWS

Ex-Cell-O No. 31 Thread Grinders

Grinding wheels ranging from 12 to 18 in. in diameter can be used in the improved No. 31 precision thread grinders offered by Ex-Cell-O Corp., 1228 Oakman Blvd., Detroit, Mich. Other features include an improved built-in taper grinding attachment, an increase in the number of grinding wheel speeds, an electrical system providing for increased flexibility of operation, and an improved coolant system for closer temperature control. The wheel slide on these machines has been designed for mounting the built-in taper attachment, a bracket with a set of rollers fastened to the table being placed so that the rollers contact interchangeable cam plates for various type angles. This devise causes the entire grinding wheel assembly to move forward and backward on its slide at right angles to the work axle. It also will handle combination taper and straight work or special shapes.

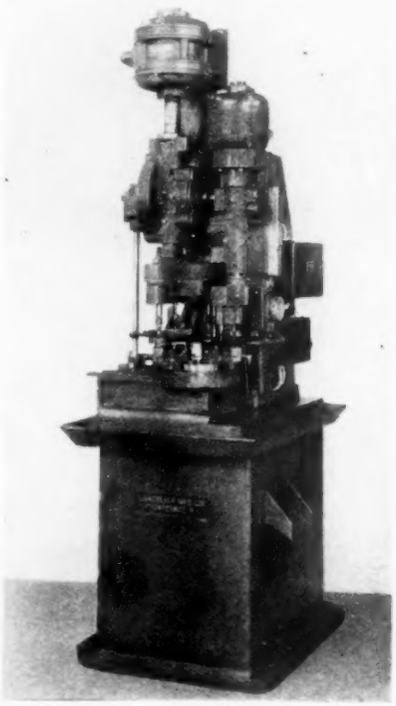
Designed to grind in both directions, these grinders are provided with manually operated diamond dressers designed so that the wheels can be dressed without slowing down the wheel. By means of interchangeable pulleys for both wheel and motor spindles, a given surface grinding speed can be obtained for any wheel size from 12 to 18 in. in increments of one inch. A speed of 7,000 surface ft. per min. is recommended for 29 deg. and Acme threads, while 9,000 surface ft. per min. is used for 60 deg., U. S. and sharp V threads.

The heavier work head, now equipped with two precision bearings, is driven from a two speed motor through worm gearing. Four-step pulleys on the motor and work spindle provide a range of eight work spindle speeds, ranging from 6 to 60 r.p.m. Tail stocks incorporate an adjustment for tension on the center to allow for variations in light or heavy duty grinding of long and short work.



Langelier 7-Spindle Drill and Tapper

Designed for machining the right- and left-hand stationary cutters of an electric razor, this vertical 7-spindle drilling and tapping machine built by Langelier Mfg. Co., Providence, R. I., can be operated continuously as as a single cycle unit. The machine requires a 30 x 40 in. floor space and contains a motor-driven coolant pump in the cabinet base. It consists of a standard No. 21 positive cam feed automatic unit equipped with a 5-spindle multiple drill head and a No. 11 unit having a two-spindle multiple tapping head with compensating spindles. Work holding fixtures are of the hand-clamping type.



Cincinnati Improved Snagging Grinder

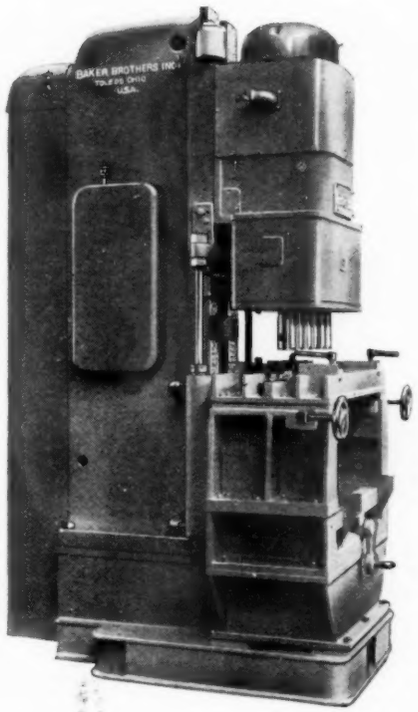
A variable-speed snagging grinder which can be furnished for use either with high-speed or vitrified grinding wheels and which is claimed to insure the correct peripheral speed for the life of the wheels has been announced by the Cincinnati Electrical Tool Co., Div. R. K. Le Blond Machine Tool Co., Madison and Edwards Roads, Cincinnati, Ohio. This grinder employs two adjustable pitch sheaves to give speed adjustment.

Adjustment of the pitch diameters of the pulleys is synchronized with

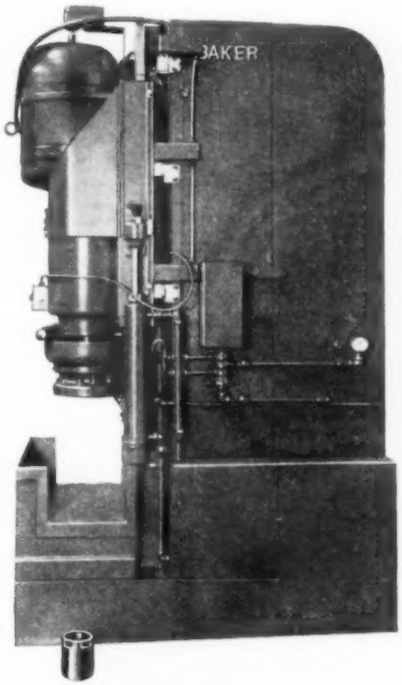
KNOWN by the Companies We Keep

The most efficient producers in the world—the large automobile companies—are among the companies we keep as customers. These production experts judge machine tools on the basis of results. Results from Baker machines have justified orders and repeat orders since the beginning of the automotive industry.

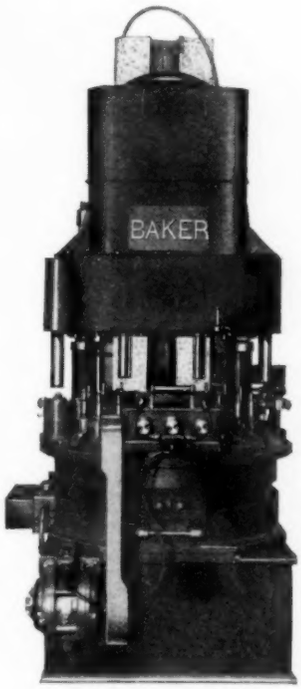
The machines illustrated are some of the Baker tools built in the past six months for auto manufacturers.



No. 30-HO motor on Saddle type machine with six cylinder preloaded ball bearing multiple head arranged to chamfer both top and bottom of cylinder bores.



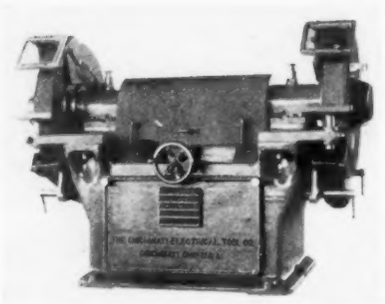
One 2 spindle 30-HO machine for boring starter frames. Machine is equipped with automatic chucking fixture hydraulically operated in conjunction with cycle of machine. When cut is finished spindles stop rotating before cutters return through work and parts are released before the head reaches the upper position. Operator holds two parts in fixture and starts machine with electrical foot control.



No. 60 HO with multiple head (note stub spindles) and fixtures for boring, hollow milling, and facing wheel cylinders. Machine is equipped with power index and power clamping. Six parts chucked at each working station; three new parts and three parts rechucked for second operation on reverse side.

If you have problems in volume or specialized production, submit your drilling, boring, reaming or tapping operation to Baker Brothers, Inc., Toledo, Ohio. New Jersey office 1060 Broad St., Newark.

★BAKER★



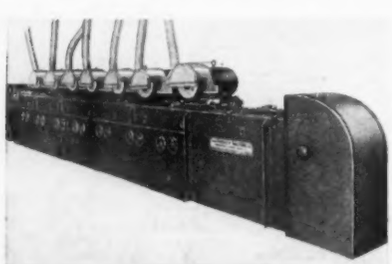
the movement of the wheel guards and spark breakers, thus making it impossible to over-speed the wheels. A shaft locking device is provided to facilitate changing grinding wheels. Grinder can be furnished to carry wheels up to 30 in. in diameter and can be fitted with motors up to 15 hp.

Westinghouse Type HD Pushbutton Stations

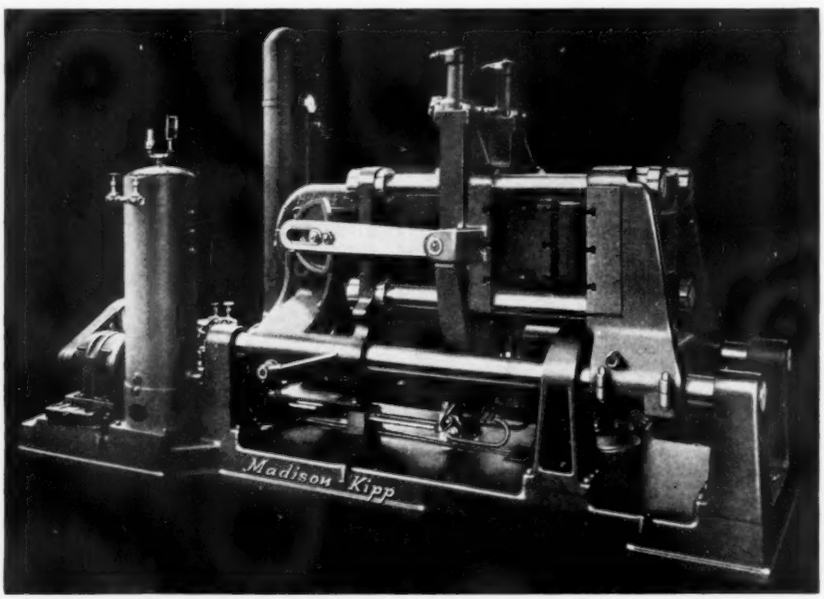
Type HD heavy-duty pushbutton stations developed by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., now are available with mushroom-type operating heads. These heads can be used on any one or all buttons in the station.

Packer No. 2 Line-Type Polishing Machine

A straight-line conveyor-type machine for finishing a variety of shapes and size of parts has been announced by the Packer Machine Co., Meriden, Conn. The No. 2 automatic seven-spindle polishing and buffing machine shown is 30 ft. 6 in. long and 4 ft. 6 in. wide. Wheelheads are of the No. 6500 universal type, with adjustments for setting the wheels at any angle from horizontal to vertical. These wheelheads are arranged with spring balance plates, thus providing a flowing action to the wheels to compensate for any lack in uniformity in thickness of the part being finished. Adjustment for changing the position of the wheel is at the front of the conveyor, permitting the operator to adjust each wheel from the operating position. Conveyor chain is driven by a variable speed unit.



Madison-Kipp 400-Series Cold-Chamber High-Pressure Die Casting Machines

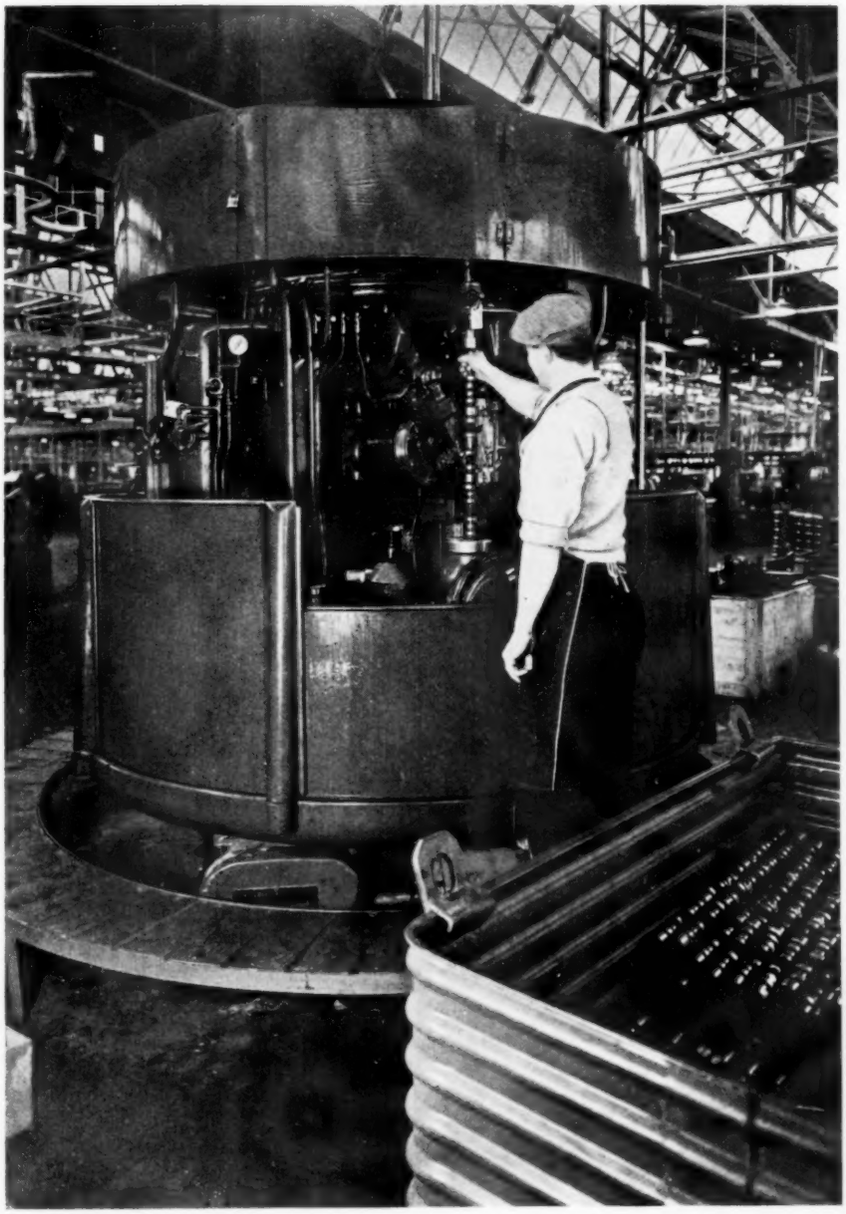


To provide for production of die castings made from various alloys of aluminum, magnesium and brass, the Madison-Kipp Corp., Madison, Wis., has developed the 400-Series cold-chamber, high-pressure die casting machines. These are made in three sizes, the smallest having capacity for aluminum castings up to 0.9 lb. including the casting and gate and known as the No. 400. This machine, when used for brass, has a capacity of 1.5 lb. for both casting and gate and a capacity of 0.6 lb. for magnesium. Total injection pressure on the metal in the No. 400 machine is 19,000 lb. The intermediate size, known as the No. 440, has a total injection pressure on the metal of 38,000 lb. Weight of the gate and casting in this machine may be 2 lb. in aluminum, 1.2 lb. in magnesium, 5 lb. in zinc, and 3 lb. in brass. The larger size machine No. 404, has a total injection pressure on the metal of 63,000 lb. This unit, shown in the accompanying illustration, has rated capacities for gates and castings of 3.25 lb. in aluminum, 2.6 lb. in magnesium, 7.4 lb. in zinc and 2–4½ lb. in brass.

All of these machines force the molten metal into the die space by hydraulic power. Locking mechanism holding the die closed during the casting period also is operated hydraulically. This mechanism is arranged to eliminate all strain on the die moving mechanism. Molten metal is handled in such a way as to obviate any danger of contaminating the alloy with iron. These machines are equipped with a dwell-cam crank mechanism to accomplish the closing and opening strokes of the die carriage and to place and withdraw cores in and from the die. These cold-chamber machines have a separate melting furnace and crucible and successive shots of metal are ladled into a well under the die. The machine may be set to run automatically, with a finished casting removed and a new shot of metal ladled into the well, manually, during each cycle. If necessary, operation may be interrupted by depressing a foot treadle at the completion of each cycle. Net weight of these machines ranges from 5,392 lb.

HIGH PRODUCTION MACHINES

for High Production Profits

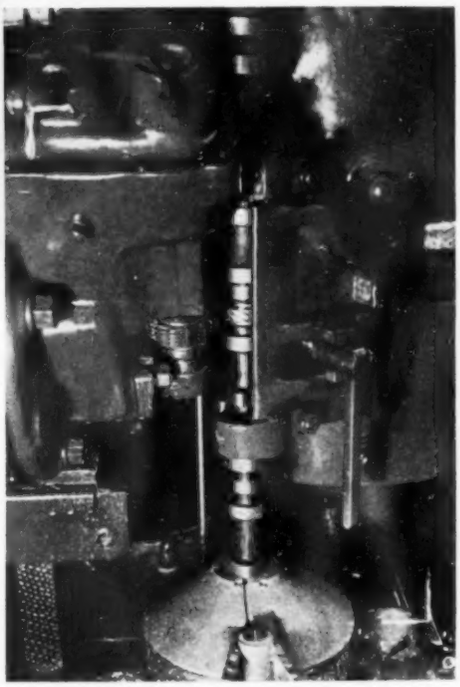


Better profits through better production methods and machines are possible today—and Lees-Bradner has long maintained a leading position in providing industry with such equipment. A typical example is the new Lees-Bradner Rotary Type Hobbing machine, one of the five of which are in operation in one of the largest and most modern plants in the motor car industry, is shown here.

This machine is cutting gears on camshafts at the rate of 120 finished pieces per hour. Four spindles for the high speed production rate are provided in this machine—one operator loading and unloading at one station. Machines are fully automatic except for loading and unloading the work.

Lees-Bradner Rotary Type Hobbing machines are adaptable to a wide range of work including the cutting of spur gears, worm wheels, helical gears up to and including a helix angle of 45°, right or left hand, spline shafts, straight or taper serrations. A modern tool for modern requirements which quickly amortizes its cost in high production.

Lees-Bradner also builds Thread Milling Machines, Single Spindle Gear Hobbing Machines, Gear Grinders and Gear Testers. Ask for descriptive literature or ask our representative to call.



THE LEES-BRADNER COMPANY

General Offices at Cleveland, Ohio—6210 Carnegie Avenue

Sales Representatives in Detroit, Chicago, New York, Philadelphia, Pittsburgh and Los Angeles

FRENCH REPRESENTATIVES

Dufour Pere Fils et Cie, 11 Rue Nueve de Villiers Levallois, Perret, Seine, France

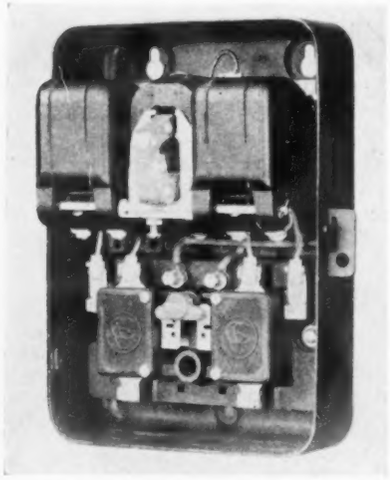
ENGLISH REPRESENTATIVES

The Catmur Machine Tool Corporation, London, England

for the No. 400 unit to 25,175 lb. for the No. 404 machine. Dies of the largest unit are locked together with four hydraulic wedge locks to hold over 750,000 lb. of casting pressure. This machine has a stroke of 12½ in. and is 14 ft. long, 5 ft. 7 in. wide and 8 ft. 8 in. high.

Clark-Sundh A.C. Automatic Starter

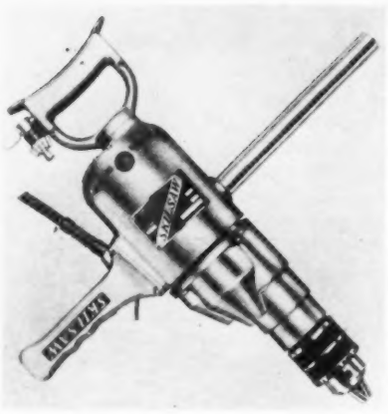
Bulletin 6013 a.c. automatic starters manufactured by The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio, are designed for across-the-line starting of squirrel cage



motors. These starters also may be used as primary switches for wound rotor induction motors. The unit shown is equipped with a bulletin 7322 a.c. mill-type thermal overload relay for 600 volt service. On larger sizes of these starters, a magnetic overload relay is used.

Skilsaw Special-Duty Electric Drills

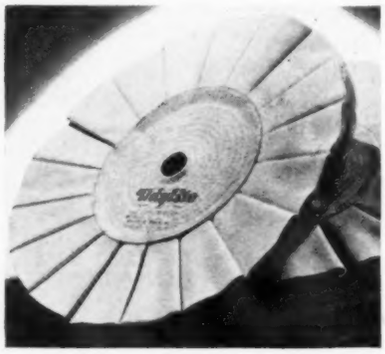
Three special-duty electric drills of ⅝, ¾ and ⅞ in. capacity and featuring low speed with high torque have been announced by Skilsaw, Inc., 230 N. Michigan Ave., Chicago, Ill. Model 101 drill has a ⅝ in. capacity in steel, a non-load speed of 300 r.p.m. and is recommended for maintenance service. It is 18¼ in. long and weighs 16¼ lb. Model 121 drill has a ¾ in. capacity in steel, a no-load speed of 250 r.p.m. and is recommended for intermittent production drilling. It is 18¾ in. long and weighs 18¾ lb. Model No. 141 is equipped with a No. 3 Morse taper socket, is 19½ in. long, weighs 17 lb., and has a ⅞ in. capacity in steel. No-load speed of this unit is 200 r.p.m. All three



models feature triple reduction, helical-cut gears and anti-friction bearings.

Udylite "Masterfold" Polishing Buff

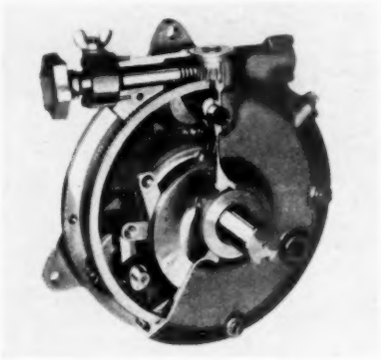
Cloth in the "Masterfold" buff offered by The Udylite Co., 1651 E. Grand Blvd., Detroit, Mich. is folded in such a manner as to present a multiple of cloth edges to the work, and to provide air spaces between the



cloth ply to dissipate friction heat generated by pressure of the buff on the work. This is claimed to be a fast cutting buff and composition is held so that the efficiency of the buffing operation is maintained with fewer applications to the wheel. Best results buffs are said to be secured at 8,000 surface ft. per min.

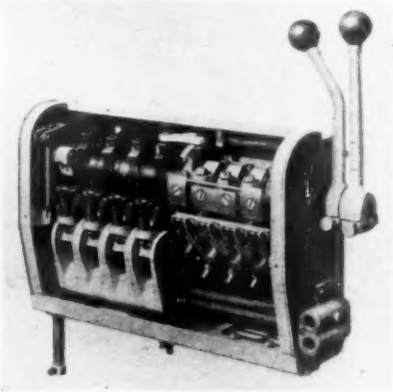
Morse Variable-Speed Control

A positive mechanism governing the speed of output shafts through an infinite number of variations within the range of the unit is provided by the variable-speed control announced by Morse Chain Co., Div. Borg-Warner Corp., Ithaca, N. Y. With the input shaft operating at the recommended speed of 180 r.p.m., this variable-speed control unit can be adjusted by a hand to deliver from 1½ to 40 r.p.m. through the low speed shaft, or any speed between these two limits. This is a self-contained unit and is claimed not to be affected by dust or dirt conditions. It is easily installed, being coupled to the shaft and bolted on the machine frame by three bolts.



Y. & T. "Cam-O-Tactor" Electric Truck Controller

Combining high current interrupting capacity with the positive action and safety of mechanical cam operation, the "Cam-O-Tactor" control developed by the Yale & Towne Mfg.



Co., 4530 Tacony St., Philadelphia, Pa., is being used on Yale electric industrial trucks. An interlock is provided so that the controller must be returned to neutral before reversing. Controller is mounted in a heavy steel case on a die-molded insulating base.

Synthane Glass-Fabric Laminated Material

Using a woven-glass fabric in place of the usual paper or fabric base, a Bakelite-laminated material offered by Synthane Corp., Oaks, Pa., is said to have increased resistance to the action of corrosive liquids. The material is said to show a low moisture absorption and a minimum change in the electrical characteristics.

NEWS OF THE INDUSTRY

Allegheny-Ludlum Opens New Alloy Steel Exhibit

These companies are expected to merge on August 10

NEW YORK—Sponsored by the Allegheny Steel Co. and the Ludlum Steel Co., specialists in the field of alloy steels, a new exhibit, "Steels of Today and Tomorrow," was recently opened at the New York Museum of Science and Industry. A preview of the exhibit was attended on June 15 by a group of representatives of the press, the banking fraternity and industry.

H. G. Batcheller, president of Ludlum, explained that the exhibit departed from the conventional pattern. Instead of emphasis on the skyscraper and other uses of great tonnage, stress was placed on the multitude of complex new alloys and the interpretation of their uses to the potential user.

Included in the latest developments shown at the exhibit is Ludlum's procedure for coloring stainless steel. This is not a mere application of color, but coloring which is in the steel and which enhances the corrosion-resisting and stainless properties of the metal. The exhibit of Ludlite stresses the ease with which this paper-thin stainless steel can be handled and applied to the conventional kitchen or bathroom. A natural color talking picture of steelmaking operations is in continuous operation.

Ratification of a merger of Allegheny and Ludlum is to be voted upon at a special meeting on August 10. W. F. Detwiler, now president of Allegheny, is to be chairman of the board, and Hiland G. Batcheller, now president of Ludlum, is to be president of the new Allegheny Ludlum Steel Corp. Of the nineteen new directors, twelve will be from Allegheny and seven from Ludlum. Total assets of the new corporation will be $31,815,060, based on reports of Dec. 31, 1937.

Little duplication of equipment or products will occur from the proposed merger. Both companies produce stainless alloys: Allegheny making sheet, plate and tubular products, and Ludlum producing wire, forgings and castings, and hot-rolled and cold-finished bar products for the production of which Allegheny has only limited facilities.

Each company has developed alloy steels, but none of the products of either company are materially duplicated by the other. About 75 per cent of Allegheny's capacity lies in open-hearth steels, which Ludlum does not produce. Allegheny's electric furnace steels consist largely of special alloys for the electrical equipment industry, whereas Ludlum is a large producer of tool steels, valve steels and wear-resistant steels.

T. G. Delbridge Heads Testing Society

ATLANTIC CITY—At the 41st annual meeting of the American Society for Testing Materials, which convened here on June 27, the following slate of officers was elected: president—T. G. Delbridge, manager of the research and development department, Atlantic Refining Co.; vice-president (for two years)—W. M. Barr, chief chemical and metallurgical engineer, Union Pacific Railroad Co.; members of the executive committee (for two years)—A. T. Goldbeck, engineering director, National Crushed Stone Assn.; Dean Harvey, materials engineer, central material and process engineering department, Westinghouse Electric & Mfg. Co.; G. E. Hopkins, technical director, Bigelow-Sanford Carpet Co., Inc.; Allen Rogers, supervisor, course in industrial chemical engineering, Pratt Institute; J. J. Shuman, inspecting engineer, Jones & Laughlin Steel Corp.

A.G.M.A. Schedules Meeting for October 10-12

Skytop Lodge in the Pocono Mountains of Pennsylvania will be the scene of the semi-annual convention of the American Gear Manufacturers Association, according to an announcement by Howard Dingle, president. U. Seth Eberhardt is arranging an attractive program.

Johns-Manville Seeks Public's Viewpoint

NEW YORK—Interpretation of the public's viewpoint to the board of directors of the Johns-Manville Corp. is to be undertaken by Dr. Walter A. Jessup, who was elected to the directorate on June 20. In explaining this move, Lewis H. Brown, president, said that it was done in recognition of the new era of broadened social responsibility now confronting American industry. Dr. Jessup will assist the board in correlating modern policies with these newer concepts. He is president of the Carnegie Foundation for the Advancement of Teaching and has had a fine record in pioneering the study of social and economic questions of the teaching profession. For seventeen years he was president of the University of Iowa. Since 1933 he has been president of the Carnegie Foundation.

W. B. Phillips Elected by Electro-Platers Society

MILWAUKEE—Four hundred and forty-nine persons registered for the 26th annual convention of the American Electro Platers Society at the Hotel Schroeder, June 13–16. Asbury Park, N. J., was chosen as the place for the 1939 annual convention to be conducted jointly with the International Electro Depositors Technical Society of London. Arrangements for the 1939 convention are in the hands of the Society's Newark, N. J., branch and the date will probably be in June.

Officers elected for the ensuing year are: president, William B. Phillips, metallurgist, Chevrolet Division, General Motors Corp., to succeed A. B. Wilson of Chevrolet; first vice-president, Ray Goodsell, Racine Plating Co.; second vice-president, Frederick Fulforth, Proctor Electric Co.; third vice-president, Joseph L. Downs, Remington-Rand Co.; executive secretary, W. J. R. Kennedy. Two additional honorary members of the Society are Walter Barrons of the Canada Cycle & Motor Co., Toronto, and Phillip Sievering of Newark.

A.S.M.E. Nominates Officers for 1939

ST. LOUIS—At the banquet on June 22, which climaxed the summer meeting of The American Society of Mechanical Engineers, the nominating committee reported through secretary C. E. Davies the slate of officers for the coming year. The slate will be voted on this summer and the new officers will assume their duties at the annual meeting in December.

Prof. Alexander G. Christie, Johns Hopkins University, well known as a consulting engineer both here and in England, was nominated for president. For vice-presidents to serve two years the committee selected W. Lyle Dudley of Seattle, James W. Parker of Detroit, and Alfred Iddles of New York. H. H. Snelling of Washington was picked to fill out the unexpired term of vice-president B. M. Brigman, deceased. Since he cannot take office until December the council selected W. A. Shoudy of New York, former vice-president, to serve until then. The new managers, who will serve three years, are Clarke Freeman of Providence, W. R. Woolrich of Austin, Texas, and W. H. Winterrowd of Chicago.

Good Year Expected for Farm Equipment

CHICAGO—Sales of all farm equipment, including tractors, are estimated to be currently running 30 to 35 per cent behind 1937, and for the year to date are about 20 per cent behind a year ago. Despite the slump the 1938 volume may still be above the best since 1930, except for the 1937 record. If the indicated prospective decline in sales applies to the industry as a whole, domestic volume would drop to around $400,000,000 which would be about as good as 1936, when sales were $409,000,000. Sales last year are tentatively estimated at $532,000,000. Foreign business (implement and tractor) is making a better showing than domestic. Estimates are that so far in 1938 foreign sales are running about 20 per cent ahead of 1937. Prospects are that the gains for the year as a whole will not be so great. Good business is looked for from Canada, which is entering a new crop season under the best conditions in years. Argentina and Australia have furnished a consistent market but England and France, both experiencing droughts, have not held up so well.

Fairbanks, Morse & Co., feels pretty good about the recent award of $2,880,801 navy contract for diesel engines for three new submarines. It was reported that the twelve engines will increase production from four days a week to full time at The Beloit, Wis., plant.

Bath Iron Works Bid Low on Destroyers

WASHINGTON—The Navy Department has revealed that the Bath Iron Works entered the lowest bid for 1,500-ton destroyers on its construction list, which calls for four such vessels. Bath asked $6,053,000 for one and $5,315,000 for each of two. The other two ships are likely to go to Federal Shipbuilding & Drydock Co., which asked $5,382,000 for each. Electric Boat, the only bidder on three submarines, wanted $3,407,000 for each. The lowest bid for fleet tugs was entered by the New York plant of the Bethlehem Shipbuilding Corp., which bid $1,288,000 for each of the three.

H. A. Smith Show Drew 1,000 Persons

SYRACUSE, N. Y.—More than twenty lines of machine tools, presses, small tools, degreasers, woodworking machinery and welding equipment were demonstrated by factory representatives at the Machinery Show sponsored by the H. A. Smith Machinery Co. from June 13–18. Approximately 1,000 people visited the Smith showrooms from 9 a.m. Monday to 9 p.m. on Saturday, according to an estimate by R. M. Carter, Smith's president and treasurer. Some sales were made despite present conditions, and prospects for future orders were materially enhanced by the demonstrations afforded the visitors.

Equipment shown included: Oster bolt threaders, Hardinge lathes, milling machines and collets, Monarch toolroom lathe, Rockford hydraulic shaper, Edlund drilling and tapping units, Federal inclinable press, Peerless high-speed metal saw, Maag gear grinders, USL arc welders, Thompson automatic broach grinder, Fosdick radial drill, Sundstrand Ridigmil, American general-utility hydraulic press, Barnes honing and drilling machines, Whitney abrasive cut-off machine, Westcott angle-jaw chuck, South Bend lathes, Reid Bros. surface grinder, High Speed Hammer Co.'s hammer and also a drilling machine, and Blakeslee degreaser.

Japanese Orders May Come Through Soon

NEW YORK—World-wide sales of new machine tools have been dull according to dealers here. Russia, the big buyer, doesn't place much of its business in this city. Japan, the other good source of orders until recent weeks, is still withholding exchange permits.

England has been inactive for some time. Central and South American countries are showing some improvement, notably Columbia, Mexico and Argentina. Even some business has been placed by Brazil on a satisfactory cash basis.

Just when Japan will release the flood of orders accumulating in the offices of her buying agents is still anybody's guess. Millions are in prospect.

A Japanese commission is in New York now and the story is that some good orders will come from this visit in about two weeks.

Incidentally, machine tool firms dealing through established agents for the Japanese Government have little to fear from the warning given exporters by the Department of Commerce. Such agents are not likely to jeopardize their position in this country, and will work for the protection of their sources of supply. The warning is construed as applying to such American companies as try to deal direct with firms in Japan, and here the Department of Commerce is giving sage advice in suggesting that "confirmed, irrevocable letters of credit" be secured before exporting goods.

Some improvement has taken place in export orders for used equipment, and prospects are better. Sales have been spread out to all parts of the globe. England, Italy and France have taken some tools. Those going to England will probably be rebuilt and find their way into armament plants. The French are more concerned with semi-heavy tools of general-purpose nature. Good-sized orders from Czechoslovakia and Greece are likely to come through soon.

Australia, India and the Far East have been buying used and rebuilt machines. Even war-torn China is thinking about placing a nice piece of business. Competition is keen in South America, since both English and German Firms are anxious to share in the used and rebuilt machine market. Some dealers complain that prices are too low and that profits are small.

DETROIT LETTER

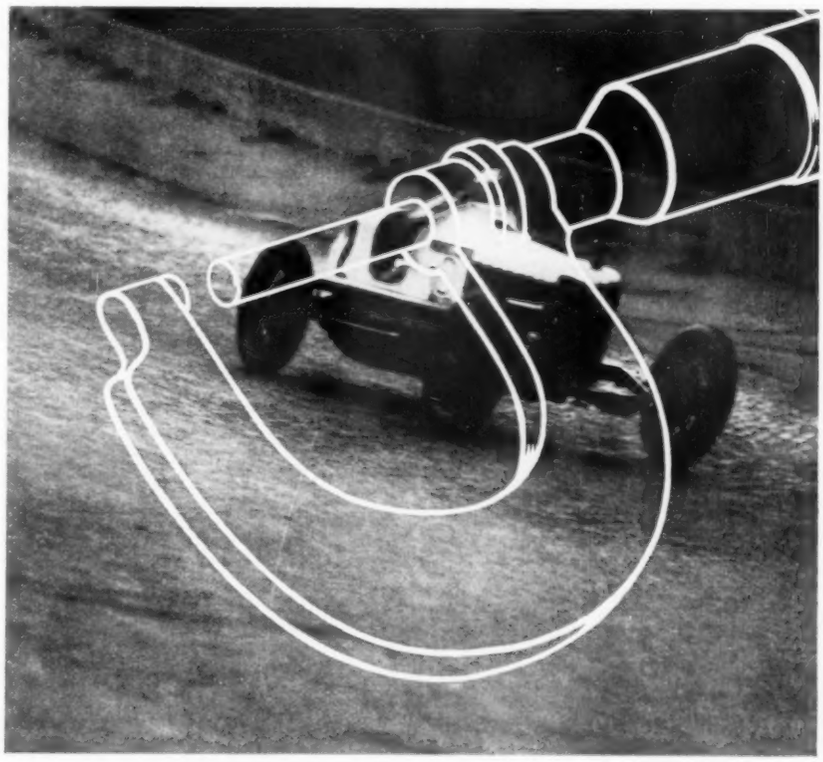
DETROIT—That automotive folks haven't taken to heart Mr. Sloan's prediction that next year's output may dip down to the 1932 level is indicated by a shift in sentiment toward the optimistic side. Detroit has been the gloomiest place in the country for months. Strangely enough, the gloom has begun to lift just at the beginning of what will be the lowest period of the year from the standpoint of production. Yet there is some basis for the change in psychology.

Perhaps the foremost factor is that retail car sales have not slipped seasonally to the extent anticipated. Though the sales volume is far below a satisfactory point, the June record is good when compared with May's. Truck demand, in particular, has been holding up moderately well. Whereas passenger car sales were off 48 per cent in the first four months of 1938, truck sales declined 39 per cent. International's registrations from Jan. 1 to April 30 were off only 22.5 per cent from the same months a year ago. Chevrolet was down 29 per cent and Dodge 31 per cent. Ford, on the other hand, took a licking to the extent of a 52 per cent drop. One should remember, however, that this comparison is with a period in 1937 during which the General Motors and Chrysler strikes occurred.

The reasonable stability of the retail car market is enabling automobile companies to hold their production of current models longer into the summer than expected. This means that shutdowns for retooling will not be so prolonged as the public had been led to believe. The industry has taken pains to dispel the idea that there were to be concerted closings of factories for two or three months. The outlook is promising for continuation of part-time employment in southern Michigan on a fair scale through most of the summer. As is normally the case, parts manufacturing plants will be inactive while assembly lines still are busy, and work on 1939 parts will be well under way while assembly lines are down. The actual "down time" will not be greater than in any average year.

The approach of a new model season enlivens the spirits of Detroiters. This year is no exception. Buick is reputed to have placed the first steel releases for its new jobs and Ford is expected in the steel market soon. Manufacture of parts for '39 lines also is beginning to get under way. Incidentally, Ford is reported to have used very little outside steel in the first four months of this year, because production must be well over 3000 units a day to get beyond Ford's own steel-making capacity at the Rouge plant.

Improvement in sentiment doesn't signify that business will be "hot" in the Fall. Car makers haven't changed their minds about turning out cars cautiously to stock dealers, after which they will wait to see what happens. Opinion in automotive circles about 1939 is divided. One group feels that production will be about the same as this year. That would be around 2,000,000 units.



PRECISION

Without precision, present day racing speeds would not be possible. In the manufacture of automobiles, measurements that are "good enough to get by" won't do. Accuracy to the most exacting limits is insisted upon — and it's precision of this kind that has enabled the world to reach its present high stage of industrial development.

The Lufkin Rule Company plays an important part in this game of precision and industrial progress. For over fifty years it has pioneered in developing better measuring devices. That's why Lufkin Precision Tools are to be found in the hands of outstanding engineers and mechanics everywhere.

If you haven't a copy of catalog No. 7 showing the complete line of precision tools, write for one today. It will be sent to you free of charge.

SOLD THROUGH DISTRIBUTORS

NEW YORK 106 Lafayette St. THE LUFKIN RULE CO. SAGINAW, MICHIGAN Canadian Factory WINDSOR, ONT.

Another group looks for a gain of 20 per cent. The point is that talk about sinking to the 1932 level has disappeared.

Changes for next year aren't startling, but they are more than one might think at first glance. All Chrysler cars intend to go to coil springs for front-end suspension. It will be recalled that back in the days when knee action first appeared, Plymouth and Dodge adopted coil springs at the front. Later, presumably because of the extra cost involved, the practice was abandoned and leaf springs came back. In 1939 Ford will be about the only sizable maker with leaf springs at the front of the car. The Dubonnet enclosed-type of knee action is scheduled to pass out of use next year.

Finger-tip control of gear shifting is due for a bigger play on '39 models. It is considered only a matter of time until location of the gear shift in the middle of the car's front compartment is entirely eliminated. After the public becomes accustomed to finger-tip shifting, the next move will be toward adoption of automatic transmissions. The industry knows that the public cannot be rushed into adoption of new features, hence no effort is being made to push automatic transmissions too fast.

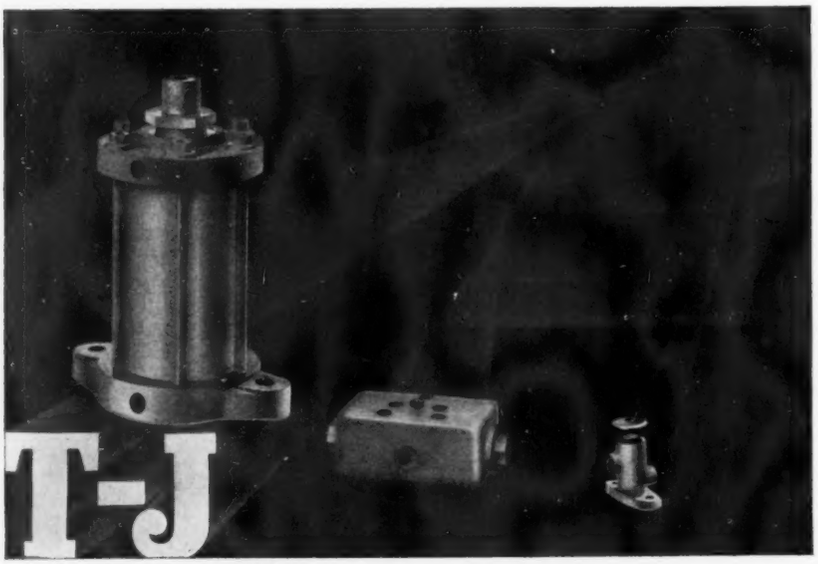
On the appearance side, further strides will be taken to give 1939 models freer flowing lines. The Lincoln-Zephyr and the Cadillac 60 will serve as patterns for other cars. It is interesting to note that Lincoln sales this year have been pushed down only 29 per cent, compared with a decline of 48 per cent for the industry. Cadillac has been the pacesetter, with a sales total nine per cent ahead of the same period of last year.

The trend is still towards cars with wider seats and more interior space and toward eventual disappearance of running boards. The car style leaders today have either narrow running boards or none at all. Wheelbases are not likely to change the coming year. Engine power may be slightly greater because of refinements perfected recently.

If Ford had any intention of putting a new small car on the market this Fall, the plan evidently has been shelved. There are no signs that Crosley will jump into the low-price field with a midget car, despite reports to the contrary. Crosley is understood to have designed a baby car and to have made dies for it which are stored away for possible future use. Powel Crosley, Jr., is known to have been working on a plan to get the cost of such a car down to a point where it could be priced for less than $300. Beyond that, there is no tangible evidence regarding Crosley's program.

Ford is reported to be convinced that this year is no time to bring out a car in the model T price class. The reasoning is that factory workers are in no position to buy any kind of new car just now, though it might be priced as low as $350. The higher price cars—Buick is a shining example—have fared pretty well this year as contrasted with low-price cars.

General Motors has announced that it will build 215,000 cars and trucks from July 1 to October 31, including the initial quantity of 1939 models. Plants will be shut down about three weeks longer than they were a year ago. This is hardly a fair comparison, however, because the change-over period in 1937 was the shortest on record. All G.M. plants will be back in production in September. As usual, factory closings will be staggered.



REMOTE CONTROLS

You See Here the Three Primary Units in this pneumatic control system which apply on your presses or other machines for pneumatic push button operation. They secure maximum possible machine speeds while safeguarding workers. They remove manual effort from the machine operation.

The **POWER CYLINDER** attaches to clutch, trip or other actuating element. It is actuated by the power valve.

The **POWER VALVE** controls the application of air pressure to the cylinder to start and stop the machine movements. It is actuated by one or more of the button valves.

We have prepared detailed information (Bulletin No. 3) so that you can see how the equipment may meet your needs. May we mail it to you?

The **BUTTON VALVE** controls supply of pressure to the power valve, serves as the actuating medium for the system. It is available in all required designs for simple or complex inter-locking control, for hand, foot, cam or lever operation, singly or in multiple; can be located in any desired position.

THE TOMKINS-JOHNSON CO.

615 N. Mechanic Street **Jackson, Michigan**

European Representative: GASTON E. MARBAIX, Ltd., London

WATCHING WASHINGTON

McGRAW-HILL WASHINGTON BUREAU
(*Paul Wooton, Chief*)

WASHINGTON—Transportation, industry, interstate commerce, and agriculture were brought under federal control, one by one. Now come 35,000,000 workers, the last great independent division of earning power, under the wage-hour law.

The law sets minimum wages at 30 cents after one year and maximum hours at 40 after two years. It places an administrator in the Labor Department, who, with the advice of several hundred industry boards, will try to bring all American workers to a 40-40 standard within seven years. Those bare facts are all that is certain about the law. It is not really a law but is a kind of labor magna carta, a basic policy of Congress, on which a law will be built. The building process may take many years.

Washington now realizes that the North-South wage-rate differential, the hottest potato on the wage-hour platter, was tossed to the administrator and his impotent boards. What will the little NRAs do with this great problem? If they try to maintain the South's "natural advantages" with low wages, will the administrator go along with them? It all depends on who the administrator happens to be. If he doesn't cooperate, how long will the South prolong the uncertainty in a fight for amendments? These questions are unanswerable but they may serve as pointers to study of developments.

Of course the President will be hard pressed to appoint a Southerner as administrator who presumably would overrule any board recommendations contrary to differentials. One thing is taken for granted: The administrator will be a pro-labor follower of the administration. Rumored for the job: Leon Henderson, WPA economist and former NRA executive; Isador Lubin, Commissioner of Labor Statistics; Lloyd Garrison, Dean of University of Wisconsin Law School; Ed McGrady, former Assistant Secretary of Labor.

Beside the differential, there are more unanswerable questions. How will the boards—spokesmen for employers, employees, and "the public"—team up? Will employer and public delegates join for low costs and low prices, keeping wages below minimum? Who is the public anyway, if not employers and employees? Will this law spread employment? If it does, is the inevitable result lower wages for high-bracket earners? Will it disemploy the low-scale earners who, employers say, are not worth the minimum rate? Will it increase manufacturing costs and combine with Mr. Hull's low tariffs to open the door to foreign goods?

More important to the metal working industry than wage rates provided in the law is the hours provision. Section 7 say that employment in excess of hours specified (44 to 42 to 40 in the third year) shall be paid time and a half. The employer can

THE LAST WORD IN MODERN ENGINEERING DESIGN

»

JACOBS BALL BEARING SUPER CHUCKS

IF IT'S A *Jacobs* IT HOLDS!

THE JACOBS MANUFACTURING COMPANY
HARTFORD, CONNECTICUT, U.S.A.

work labor longer weeks than specified only under agreement with unions certified by NLRB, limiting hours in 26-week periods to 1,000, or 2,000 in 52 weeks. But the AFL unions vigorously oppose and do not enter into such agreements. They say the employer could work employees excessive hours as long as necessary, and then fire them. The industry, therefore will have to pay time and a half for over-time, or find other men for part time or an extra shift.

Other laws by the third New Deal Congress directly affecting the metal-working industry:

TAXES—The 1939 revenue act didn't please the President and it became law without his signature. It greatly modified undistributed profits taxes on corporations and set up flat capital gains taxation.

ANTI-TRUST—An authorized investigation by a joint committee from Senate, House, and several government departments and commissions points toward anti-monopoly law next Congress which may affect steel, aluminum, farm machinery, patents, and other interests.

INDUSTRIAL LOANS—Glass amendment to RFC law liberalized and lengthened terms as aid to business.

RFC industrial loans jumped from 44 aggregating $5,615,078 in March to 107 for a total of $15,166,180 in April. The Glass amendment liberalizing terms became effective April 13. Then in May total loans stepped up to 290 totaling $25,000,000. These figures are authorizations. Considerable amounts are regularly cancelled or withdrawn later.

Business representatives in Washington are pleased about this aid to small business, but they wonder how many borrowers have got into trouble during the new depression—how many are about to be sold out or placed under virtual government operation. RFC is bound to come in for some Shylock criticism. But its friends will say that business asked for the loans and got them. Total industrial loans authorized since the RFC act is 2,828, aggregating $210,000,000. The corporation has purchased or agreed to purchase participations in 520 businesses aggregating $33,000,000.

BANKRUPTCY — Chandler law takes some 50-year-old creaks out of an unhappy procedure.

EDUCATIONAL ORDERS—Provides $2,000,000 for each of five years with which War Department will place negotiated (no bid) practice orders for special munitions.

For twenty years the War Department, supported by the metal-working industry and by *American Machinist*, has tried to persuade Congress to establish a system of educational orders for munitions of special design. This legislation was passed in the last hours of Congress, and the department is now studying types of equipment to be manufactured and methods to be adopted in alloting orders to commercial plants.

Orders will cover items selected by ordnance, aviation and other arms of the service for such "pilot" production. Government tools, jigs, dies and fixtures will be loaned to manufacturers among whom orders are distributed. The law authorizing $2,000,000 a year for five years stipulates that no more than one order for the same or similar article shall go to the same firm in three consecutive years. Unofficial advice by the department is that plans for the administration of the law will not be announced for several weeks at least.

New 48-page illustrated booklet entitled "The Story of Sulphurized Cutting Oils" now available to personnel of metal working plants. Please write to 2727 South Troy Street, Chicago, for your free copy using company letterhead and stating capacity.

SOUTH TO MECHANIZE

Much of the future of wages and hours legislation will depend on the type of personnel chosen to put the program into effect. Unfortunately the administrator's appointment will not go before the Senate for confirmation. If the recess appointee should be arbitrarily inclined, business may be disturbed profoundly. If good judgment is used in the selection, the act may be put into effect in a way calculated to secure cooperation from industry and all concerned. Everyone agrees that southern industries which use a considerable amount of common labor will be encouraged to mechanize. Many industries rather than pay overtime are expected, as hours shorten, to put their operations on a two-shift basis.

CIVIL AERONAUTICS ACT—Independent authority takes over aviation; resulting expansion will increase demand for equipment.

MERCHANT MARINE AMENDMENT—Might have helped American shipping by solving labor problem but there are no teeth in it.

CROP CONTROL—Pays big money to agriculture but curtails acreage and seems not to increase need for machinery.

BIG NAVY—Authorizes billion dollar, 20 per cent increase; probably will be built if world stays nervous; $36,000,000 voted in second deficiency to start construction.

WAR DEPARTMENT—Gets $463,651,000 for fiscal 1939, biggest since 1920, $44,000,000 ahead of this year. It's heavy on anti-aircraft, airplanes, tanks, ammunition reserves, and tools.

WINDMILLS—$2,000,000 for War Department, Coast Guard, Commerce and other departments to experiment with autogiro; may generate public demand.

Bills that would have affected the industry, but which failed:

WAR PROFITS—Would have frozen prices as of day of declaration, and established other control.

PATENTS—Would have forced licensing to applicants.

RAILROAD EQUIPMENT—Would have been bought with RFC loans.

LONG-SHORT HAUL—Would have permitted railroads to reduce long haul rates while maintaining rates to intermediate points.

TRAIN LENGTH—Would have limited cars to 70.

NRLB AMENDMENT — Would have made unions responsible and recognized employer rights.

WALSH-HEALY AMENDMENT—Would have given Labor Department control over wages and conditions on public contracts above $2,000 instead of $10,000 and set up blacklist of companies violating NRLB rulings.

FEDERAL LICENSING—Would have established omnibus for government control of labor, fiscal, and monopoly practices.

Leipzig Fall Fair

The 1980th session of the Leipzig Trade Fair will be held from August 28 to September 1, at Leipzig, Germany, and will comprise some 6,000 exhibits from 32 countries. Two large exhibition halls have been added to the 42 buildings previously in use. Attendance of a quarter of a million exhibitors and buyers from 74 countries is forecast. Technical products will be shown, but not in the same volume as the Spring Fair.

Both sides are "TOPS"

ON TAFT-PEIRCE

Duplex BENCH BLOCKS

Taft-Peirce Bench Blocks have twin surfaces—accurately ground—one of which may be used for working purposes, the other reserved for reference or inspection, if desired. These plates have many uses — are often used as ready-made bases for small fixtures and tools.

Made of well seasoned cast iron, thoroughly ribbed, they can be furnished grooved for lapping or handscraped on one or both sides at a slight extra charge. Carried in stock ground only, size 10" x 14" x 2⅜". Weight 40 pounds. Special sizes on order. WRITE FOR PRICES.

THE TAFT-PEIRCE MFG. CO.

Woonsocket *Rhode Island*

Dr. J. C. Parker Heads Electrical Engineers

WASHINGTON—During the annual summer convention of the American Institute of Electrical Engineers here from June 20-24, Dr. John C. Parker, vice-president of the Consolidated Edison Co. of New York, was elected president for the year beginning August 1. The annual report of the board of directors showed a total membership on April 30 of 16,078.

PERSONALS

LOUIS POOCK, vice-president and general manager of the Sheffield Gage Corp., the Cimatool Co., Dayton, Ohio, is the new chairman of the Dayton-Cincinnati-Columbus Section of the Society of Automotive Engineers. CHARLES E. DICKERSON, president of the Miami-Dickerson Steel Co. is vice-chairman for Dayton; K. W. STINSON, professor of automotive engineering, Ohio State University, is vice-chairman for Columbus, and W. W. TANGEMAN, vice-president of the Cincinnati Milling Machine & Cincinnati Grinders, Inc., is vice-chairman for Cincinnati. E. S. PATCH, engineering and sales manager, Moraine Products Div., General Motors Corp., Dayton, is treasurer. WILLIAM S. WOLFRAM, engineer, Inland Mfg. Div. of General Motors Corp., Dayton, is secretary.

WINTHROP H. WHITNEY has been elected president of the Whitney Chain & Manufacturing Co., to succeed CHARLES E. WERTMAN, resigned. Mr. Whitney is also treasurer. He is 34, and is vice-president and a director of the Hanson Machine Co., of Hartford. Prior to heading Whitney Chain, which was founded by his father, the late CLARENCE E. WHITNEY, Mr. Whitney was associated with the SKF Industries and the Automatic Signal Co.

A. C. HOWARD has been appointed general manager of the Beloit, Wis. plant of Fairbanks Morse & Co., according to an announcement by A. E. ASHCRAFT, vice-president in charge of manufacturing. The position was formerly held by Mr. Ashcraft in addition to his executive control of all Fairbanks-Morse factories in the United States and Canada. Mr. Howard has been assistant general manager of the Beloit plant for six years.

HENRY S. WASHBURN, president of the Plainville Casting Co., Plainville, Conn., has been elected president of the H. B. Smith Co., Inc., Westfield, Mass., boiler and radiator manufacturer. A. LIONEL LAWRENCE has been named first vice-president. EDWIN W. SMITH, former president of the Smith Co. and at present chairman of the Institute of Boiler and Radiator Manufacturers, has been elected treasurer.

F. C. RUMELY has been appointed Chicago works manager for the Crane Co. Mr. Rumely was formerly connected with the Hudson Motor Car Co. and has been a past chairman of the Detroit Section, Society of Automotive Engineers.

F. J. DEMAREST is the newly elected president of Greene, Tweed & Co., 109 Duane St., New York, N. Y. H. G. RUSSELL is treasurer and general manager; J. A. MCKEON remains as vice-president and H. A. ERWOOD is secretary.

GUSTAVE F. BAHR has been elected vice-president of the Casco Products Corp., Bridgeport, Conn. Mr. Bahr is also a director and engineer for the company.

E. J. GRIFFIS has been elected president of the Peerless Bread Machine Co., Sidney, Ohio, succeeding DALLAS WINSLOW, resigned.

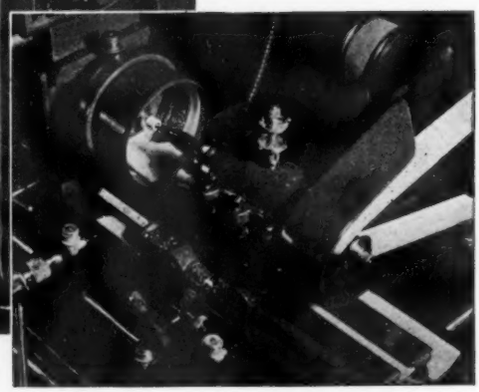
C. D. MACPHERSON of the hoist and body division, Gar Wood Industries, Inc., Detroit, was recently appointed a member of the board of directors to serve until 1940, and also placed on the executive committee of the Manufacturers' Division, American Road Builders' Association.

NEWBOLD C. GOIN succeeds L. R. BOTSAI as sales manager of the Westinghouse Electric & Mfg. Co.'s gearing division, Nuttall Works, Pittsburgh, according to a recent announcement by R. S. MARTHENS, manager of the division.

EDWARD W. SAND, 69-year-old instructor in the apprentice school, Cincinnati Milling Machine Co., has completed 55 years of service.

Small Hole Grinding

RIVETT
No. 104
INTERNAL GRINDER



Mounted wheel held in chuck grinding small bore with spindle turning at 35,000 r.p.m.

The Rivett No. 104 Grinder is designed to meet demand for a small hole grinder suitable for precision tool making and accurate manufacturing. It may be used as a single purpose machine in efficient production or readily and rapidly set up for the many varying requirements of the toolroom. Correct in proportion and design, the extremely high spindle speeds necessary for small hole grinding can be maintained within the required limits absolutely free from vibration.

Although primarily an internal grinder, an external grinding attachment can replace the internal spindle bracket. The Rivett fixed diamond method is used for truing both internal and external wheels to maintain sizes on duplicate work. For further information write for bulletin 104-C.

RIVETT LATHE & GRINDER INC.
BRIGHTON, BOSTON, MASS.

GEORGE SHEPPARD, formerly of Williamsport, Pa., has been appointed superintendent of the Gilmore Wire Rope Division of the Jones & Laughlin Steel Corp., Jersey Shore, Pa.

ROBERT GRANT has been made director and vice-president of the Fuller-Johnson Corp., Detroit, manufacturer of electrical appliances. He was former manager of assembly operations in the Nash plant at Racine.

FRANK O. PARKER, sales manager of the Acme Steel & Malleable Iron Works, Buffalo, was elected president of the Malleable Founders' Society at the annual meeting June 17, at White Sulphur Springs W. Va.

GEORGE M. VERITY was honored by the Stevens Institute of Technology, Hoboken, N. J. with the honorary degree of doctor of engineering in recognition of "an industrial administrator, who knowing men as well as materials, has conducted the human affairs of his company with such justice and consideration that in 38 years no disagreement has ever arisen between management and men." Mr. Verity is founder, president and now chairman of the American Rolling Mill Co.

DR. C. F. HIRSHFELD, chief of research, Detroit Edison Co., and past chairman and member of the Engineers' Council for Professional Development, was granted the honorary degree of doctor of engineering by the University of Detroit on Tuesday, June 7.

WESLEY P. SYKES, metallurgical engineer at the Cleveland Wire Works of the General Electric Co., was awarded the honorary degree of doctor of engineering at the 54th annual commencement exercises of the Case School of Applied Science. Development of new alloys containing tungsten and molybdenum has comprised the major part of Mr. Sykes' work for the past fifteen years.

E. O. SHREVE, vice-president of the General Electric Co. in charge of sales, was awarded the first "Marston Medal" by Iowa State College, an award initiated this year to honor outstanding achievement in engineering by its alumni.

R. H. BLACKIE, formerly at the Buffalo plant of Chevrolet Motors, has been appointed factory manager, American Bantam Car Co., Butler, Pa. Mr. Blackie has been identified with automobile manufacturing for more than 25 years and prior to his employment at Chevrolet was factory superintendent of the American Austin Co.

DR. ALAN MORRIS, formerly research engineer, has been promoted to chief metallurgist of the Bridgeport Brass Co. He will be in charge of the Physical and Chemical Laboratories as well as research activities.

OBITUARIES

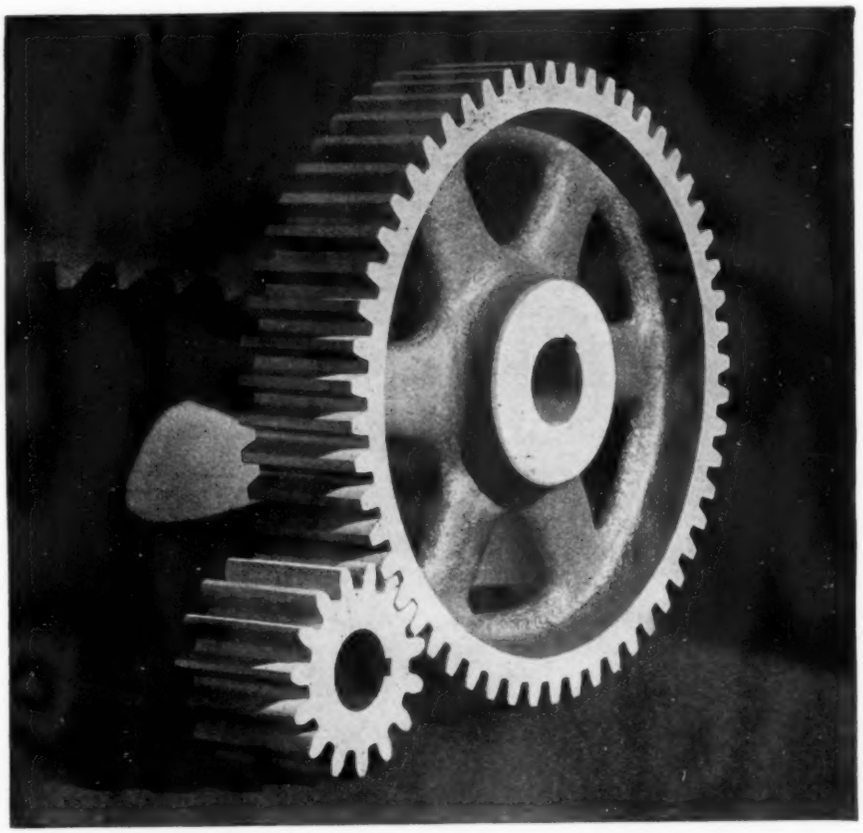
CLARENCE M. RUDEL, 63, who retired a month ago as president of the Canadian Vickers, Ltd., died June 21 in Montreal. He went there is 1902 as general manager of Canadian Fairbanks-Morse & Co., and later formed the Rudel Machine Co. In 1934 he became head of the Vickers Co.

A. B. CARSON, supervisor of the production bureau of the Pittsburgh district order division, Carnegie-Illinois Steel Co., died June 17.

JOHN ALEXANDER WILSON, member of the firm of Wilson & Brown, 30 Church St., New York, machine tool dealers, died June 13.

FREDERIC WINTHROP NEILSON, formerly president of the Sikorsky Aircraft Co., Stratford, Conn., died June 12 at Boca Raton, Fla., aged 42. Mr. Neilson began with the Sikorsky company in 1930 as sales manager. Later he was vice-president and was elected president in 1932. When the United Aircraft Co. was organized in 1934 he became vice-president and also general manager of the Sikorsky Division. In 1936 he resigned because of ill health.

THEODORE AHRENS, retired president of the American Radiator & Standard Sanitary Corp., died at Louisville, Ky., on June 12 at the age of 79. He consolidated ten manufacturers of plumbing fixtures into the Standard Sanitary Mfg. Co. and headed the organization for 30 years. In 1929 he helped to form the American Radiator & Standard Sanitary Corp., relinquishing the presidency in 1936 for a directorship.



"Spurred" for the HARDEST TASKS

● From an ounce to 20,000 pounds . . . all Horsburgh & Scott gears, whether spur or any other kind in industrial use, are of the rugged "husky" type . . . built to endure. A half century of experience, unceasing vigilance in the selection of materials and painstaking care in design and manufacture, make Horsburgh & Scott gears the finest in the world. You'll find proof in their trial.

A helpful 448 page Gear Book awaits your request.

THE HORSBURGH & SCOTT CO.

GEARS AND SPEED REDUCERS

HAMILTON AVENUE, CLEVELAND, OHIO U. S. A.

EDWIN J. BELL, president of the Bell Machine Co., Oshkosh, Wis., and a recognized authority on match-making and woodworking machinery, died June 20 at the age of 65.

FRANK FOSTER DODGE, chairman of the board and treasurer of the Atwood Machine Co., Stonington, Ct., died on June 13.

A. M. ANDREWS, chairman of the board, Dictograph Products, Inc., and one time chairman, Hupp Motor Car Corp., died June 17 at his home in Greenwich, Conn.

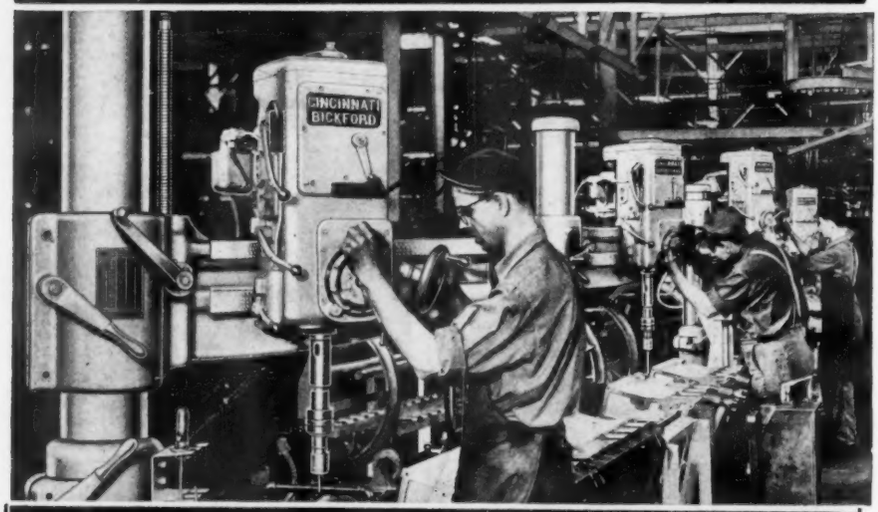
JOHN H. RANDOLPH, former vice-president, Franklin Railway Supply Co., Chicago, died June 14.

FRANKLIN A. PARK, chairman of the board, Singer Mfg. Co., Bridgeport, Ct.; vice-president of the Diehl Mfg. Co., Elizabethport, N. J., and a life member of the Massachusetts Institute of Technology, died at Woods Hole, Mass., on June 17 at the age of 70.

CARL C. KUNKLE, 55, who resigned recently as superintendent of the Transue-Williams Steel Forgings Corp., Alliance, Ohio, died June 15.

BENJAMIN F. CURTIS, 69, traffic manager of the Norton Co., Worcester, Mass., for fifty years, died June 10. He was an ex-president and a charter member of the New England Traffic Men's Association

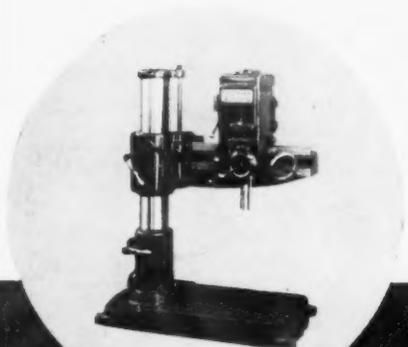
Tapping Tractor Cylinder Blocks *for Caterpillar Tractor Co.*



with NEW 2½' High Speed Super Service Radials

Production tapping is highly profitable on work such as that handled on the new Sensitive, High Speed Super Service Radials in the plant of the Caterpillar Tractor Company, Peoria, Illinois.

There are 13 of these machines in this plant. Those shown here are performing the following operations: tapping front end, tapping angular side, tapping top and tapping straight side of 4-cylinder 3¾" bore cylinder blocks.



These new 2½' Super Service Radials have a 7½" dia. column and are driven by 1 H.P. motors. Modern in every detail, flexible and easily controlled, they insure profitable hole production on a wide range of work.

Get all the details

The **CINCINNATI BICKFORD TOOL COMPANY**
Oakley, Cincinnati, Ohio

SUPER-SERVICE RADIALS

BUSINESS ITEMS

International Nickel Co., Inc., has established a new field office at Grant Bldg., Pittsburgh, Pa., under the direction of H. V. BEASLEY, to promote applications of nickel alloy steels and products of the Huntington Mill and to stimulate interest in nickel cast irons and use of nickel in non-ferrous alloys.

Detroit Rex Products Co., Detroit, manufacturers of degreasers, solvents and alkali cleaners and strippers, has opened a branch office at 111 Sutter Bldg., San Francisco, Calif., in charge of W. A. VENSEL.

Ajax Steel & Forge Co., Detroit, Mich., has appointed the Machine & Tool Designing Co., 900-905 Victory Bldg., 1011 Chestnut St., Philadelphia, as representative in eastern Pennsylvania, eastern New York State, New Jersey, Delaware, Maryland and Washington.

National Tool Co., Cleveland, has appointed the Ernest T. Gropler Co., 1060 Broad St., Newark, N. J., to represent it for hobs, broaches and other cutting tools in New York state and northern New Jersey.

Armstrong Bros. Tool Co., Apex Tool & Cutter Co., Pratt & Whitney Co., Davis Boring Tool Division of Larkin Packer Co., Wendt-Sonis Drill Works, Cole Carbide Industries and Genesee Tool Co., have signed dealer contracts with Vascoloy-Ramet Corp., North Chicago, Ill.

The Federal Steel Sash Co., Waukesha, Wis., announces that it has acquired all American rights and patents for the manufacture of Crittall casement windows and will take over the stock and machinery of the Crittall Mfg. Co., Washington, D. C. The new name for the concern will be Crittall-Federal, Inc., and all operations will be conducted in the future at the Waukesha plant.

Lyon Metal Products, Inc., Aurora, Ill., announces the appointment of H. B. SPACKMAN as vice-president in charge of sales and advertising. He was formerly with the steel products division of U. S. Gypsum Co.

Construction of a new factory addition to the Ewart Works of the Link-Belt Co., Indianapolis, will be undertaken at a cost of $300,000.

McDonald Machinery Co., 1531 N. Broadway, St. Louis, Mo., used machinery dealer, expect to move into their new quarters within the next sixty days.

Willson Products, Inc., Reading, Pa., manufacturers of goggles and helmets, have completed a $500,000 plant building program to take care of expanding business.

Arrangements have been completed between the Standard Machinery Co., Mystic, Conn., and the F. J. Stokes Machine Co., Philadelphia, whereby the latter becomes sole sales agents for the complete line of Standard plastic molding presses.

Greenfield Tap & Die Corp. will close its offices and plants as follows: Detroit plant from June 25 to July 5; Greenfield, Mass. plants from July 2-11.